2015

Annual Report of a Comprehensive Assessment of Marine Mammal, Marine Turtle, and Seabird Abundance and Spatial Distribution in US Waters of the Western North Atlantic Ocean – AMAPPS II

Short-beaked common dolphin (*Delphinus delphis*)
Collected under MMPA Research permit #775-1875
Photo credit: NOAA/NEFSC/Allison Henry

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2015 Annual Report to
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BACKGROUND

The Atlantic Marine Assessment Program for Protected Species (AMAPPS) is a comprehensive multi-agency research program in the US Atlantic Ocean, from Maine to the Florida Keys. Its aims are to assess the abundance, distribution, ecology, and behavior of marine mammals, sea turtles, and seabirds throughout the US Atlantic and to place them in an ecosystem context (http://www.nefsc.noaa.gov/psb/AMAPPS/). This will provide spatially explicit information in a format that can be used when making marine resource management decisions and will provide enhanced data to managers by addressing data gaps that are essential to supporting conservation initiatives mandated under the Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), National Environmental Policy Act (NEPA) and Migratory Bird Treaty Act (MBTA).

To conduct this work NOAA National Marine Fisheries Service (NOAA Fisheries Service) established inter-agency agreements (IAs) with the Bureau of Ocean Energy Management (BOEM), the US Navy, and the US Fish and Wildlife Service (USFWS). The products of these IAs are being developed by the NOAA Fisheries Service Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC), and the USFWS.

Since 2015 is the first year of the second IA with BOEM, the time period 2015 – 2019 is now considered part of AMAPPS II, whereas the earlier time period 2010 – 2014 is considered part of AMAPPS I.

Because of the broad nature and importance of the AMAPPS work, AMAPPS has evolved beyond the above four agencies into a larger collaborative program involving researchers from a variety of organizations. This collaborative effort has the benefit of increasing the amount of funds and personnel for field and analytical work. The network of collaborators is identified under the specific projects within the Appendices.

This report will document the work conducted by NOAA Fisheries Service during 2015.

SUMMARY OF 2015 ACTIVITIES

During 2015 under the AMAPPS program, NOAA Fisheries Service conducted field studies to collect cetacean, sea turtle, seal, and sea bird seasonal distribution and abundance data and studies to collect sea turtle and seal telemetry and biological data (Table 1). In addition, NOAA Fisheries Service continued analyzing past and present data collected under AMAPPS I and II (Table 2). A summary of the 2015 projects follows, with more details in the appendices.

Field activities

During December 2014 – March 2015 the NEFSC and SEFSC conducted two aerial abundance surveys. The line transect abundance surveys used NOAA Twin Otter airplanes targeting marine mammals and sea turtles in Atlantic continental shelf waters from Nova Scotia to Florida, from the shore to about the 200 m or 2000 m depth contour, depending on the location (Figure 1; Table 1). The aerial surveys completed about 12,700 km of track lines. Most of the marine mammals seen were short-beaked common dolphins (*Delphinus delphis*), common bottlenose dolphins (*Tursiops truncatus*), and Atlantic spotted dolphins (*Stenella frontalis*), where one group of short-beaked common dolphins was about 1200 individuals. The most frequently detected large whale was the North Atlantic right whale (*Eubalaena glacialis*), with 11 individuals. And the most frequently detected turtle was the loggerhead turtle (*Caretta caretta*), with about 280 individuals. More information is found in Appendices A – B.

One fully-molted female gray seal (*Halichoerus grypus grypus*) was satellite-tagged using an unused turtle tag that was originally purchased using AMAPPS funds. In addition, as an expansion of the AMAPPS I program, using resources from NOAA Fisheries and partners other than BOEM and USN, a team of scientists from 12 organizations conducted gray seal weaned pup live capture and biological sampling on Muskeget Island and South Monomoy Islands, MA from 11 – 17 January 2015. A suite of biological measurements and samples were collected from 128 pups. In addition, small labeled tags were attached to hind flippers. More information is found in Appendix C.

During June – July 2015, the NOAA ship *Henry B. Bigelow* was used to conduct two projects (Table 1). The first project (10 – 19 Jun 2015) surveyed waters around the perimeter of Georges Bank to document the relationship between the distribution and abundance of cetaceans, sea turtles, and sea birds and their physical and biological environment, with a focus on sei whales and beaked whales. In addition, a new infrared camera system developed by Seiche Ltd. and CSA Oceans was trialed to determine its efficiency of detecting marine mammals as compared to visual and acoustically detected animals. During over 1200 km of track lines over 2000 cetaceans and over 2500 birds were visually detected, 29 hours of passive acoustic towed array data were recorded, EK60 back scatter data were recorded during the track line sighting effort, 22 bongo/CTD casts and 24 midwater trawls were deployed. More information is found in Appendix D.

The second project on the NOAA ship *Henry B. Bigelow* conducted during 23 Jun – 2 Jul 2015 focused on tagging sea turtles located on the southern flank of Georges Bank to collect data on availability to correct visual abundance estimates and to gather biological and related ecological data. Two loggerhead turtles and one Kemp's ridley turtle (*Lepidochelys kempii*) were satellite tagged. As a pilot study the NOAA unmanned aerial system (UAS) program deployed a Puma fixed wing UAS from the *Bigelow* with the purpose to expand the ability to detect turtles. Also, in collaboration with Coonamessett Farm Foundation, three imaging systems, in addition to bongo nets, were deployed to determine the distribution of potential turtle prey, gelatinous zooplankton. The deployed systems were a video plankton recorder, a Sound Metrics Didson 300 imaging sonar, and a paired Go-Pro video net. More information is found in Appendix E.

All line-transect data have been or will be submitted to OBIS-SEAMAP and thus will be publically available at http://seamap.env.duke.edu/.

Analyses

To model the spatial/temporal distribution of marine mammals and sea turtles using data collected since 2010, two frameworks are being developed that use the same input data but different types of statistical models: Bayesian Hierarchical models and Generalized Additive models. During 2015, we further explored the sightings data; added sea surface height anomaly as an additional dynamic variable to be used in the habitat models; assessed the accuracy of the remotely-sensed environmental data values of several satellite-derived and HYCOM ocean model-derived environmental variables as compared to in-situ values of measured variables across the Northeast study region; improved the estimation of average surface and dive time of the tag data; and further developed the two frameworks to model the spatial/temporal distribution of marine mammals and sea turtles. Preliminary versions of these two frameworks were reviewed by peers in February 2015. In addition, to improve the accuracy of the visual teams' distance measurements, a NEFSC engineer is collaborating with AMAPPS to develop an electronic range finder. More information is found in Appendix F.

In 2012 a harbor seal (*Phoca vitulina concolor*) abundance project was partially funded with AMAPPS funds. This effort included aerial photographic surveys and radio tracking of harbor seals on ledges along the Maine coast during the pupping period in late May 2012. These data resulted in an estimate of 75,834 harbor seals, with a standard deviation of 11,625 and a coefficient of variation of 0.153. The results of this work were published as a NOAA Technical Memo in 2015 (Waring et al. 2015).

Passive acoustic data, which complement the visual-based data, were collected via ship towed hydrophone arrays and bottom-mounted archival recorders. Two new passive acoustic data collection projects using bottom-mounted archival recorders were initiated in 2015 and are partially funded with AMAPPS funds: the East Coast Migratory Corridor 2.0 project and the Shelf Break Acoustic Ecology project. Additionally, previously collected acoustic data are being analyzed with the goals to (1) improve estimates abundance of sperm whales (*Physeter macrocephalus*); (2) quantify acoustic detection rates for beaked whales and the potential impact of echosounder use on beaked whale detections; (3) document the offshore occurrence of baleen whales in the Great South Channel and Georges Bank regions to supplement visual sighting data; and (4) document the geographic variation in the echolocation clicks of Risso's dolphins (*Grampus griseus*). In collaboration with other researchers, the AMAPPS collected acoustic data are being used to refine an Atlantic version of a Real-time Odontocete Call Classification Algorithm (ROCCA). All the acoustic data are being archived in the Tethys database, a collaborative effort with scientists from the Scripps Institution of Oceanography and all of the NOAA Fisheries Science Centers. More information is found in Appendix G.

To gain a better understanding of the underlying processes that may drive the distribution and abundance of predators, such as marine mammals, sea turtles, and sea birds, the relationships between hydrographic characteristics of the water column and distributions of lower trophic level organisms, such as fish and plankton, are being compared relative to the distribution patterns of protected species. During 2015, the processing of the physical and biological oceanographic data collected during the two legs of the *Bigelow* cruise (Appendix D and E) started. In addition, previously collected video plankton recorder data were re-processed to create more detailed taxonomic zooplankton distributions and to provide a ground truth data set to quantify automated identification accuracy. The echosounder EK60 data were post-processed and are currently being classified into organism types. The plan is then to compare the spatial-temporal patterns of organism categories to distribution of marine mammals that were either visually or acoustically detected. These lower trophic level data collections have also provided previously unknown information on several fish species. In particular, in 2015 spawning aggregations of Atlantic herring (*Clupea harengus*) were observed in the early summer on Georges Bank, which was previously not known. Also, using previously collected bongo samples, larval bluefin tuna were collected in the slope waters between the Gulf Stream and the northeast US continental shelf, contrary to the prevailing knowledge (Richardson et al. 2016). More information is found in Appendix H.

The AMAPPS ORACLE database (housed at the NEFSC) stores sightings and effort data collected during field activities, environmental data derived from satellites and ocean models, and processed model-derived density data. The database was updated in 2015, new datasets were added, and queries for combining and outputting the data were further developed, including producing the maps of the spatially-explicit seasonal density distributions. In addition, NEFSC is developing a web-based interactive interface for managers and the public that will display the spatially-explicit density distribution maps and summarize density and abundance estimates of user-specified regions. More information is found in Appendix I.

REFERENCES CITED

Richardson DE, Marancik KE, Guyon JR, Lutcavage ME, Galuardi B, Lam CH, Walsh HJ, Wildes S, Yates DA, and Hare JA. 2016. Discovery of a spawning ground reveals diverse migration strategies in Atlantic bluefin tuna (*Thunnus thynnus*). PNAS 113: 3299-3304.

Waring GT, DiGiovanni RA Jr, Josephson E, Wood S, Gilbert JR. 2015. 2012 population estimate for the harbor seal (*Phoca vitulina concolor*) in New England waters. NOAA Tech Memo NMFS NE-235; 15 p. Available at: http://www.nefsc.noaa.gov/publications/ .

Table 1. General information on the AMAPPS NOAA Fisheries Service field data collection projects that occurred during 2015: the project name (NOAA Fisheries Service principal investigating center), platforms used, dates and general location of the field study, and the appendix within this document where more information on the project can be found.

2015 field collection projects	Platform(s)	Dates in 2015[1]	Location	Appendix
Winter abundance survey (NEFSC)	NOAA Twin Otter aircraft	5 Dec 2014 – 14 Jan 2015	Shelf waters from New Jersey to Nova Scotia	A
Winter/Spring abundance survey (SEFSC)	NOAA Twin Otter aircraft	23 Jan – 3 Mar	Shelf waters from New Jersey to Florida	B
Tag gray seal (NEFSC)	Small boats and on land	11 – 17 Jan	Muskeget Island and South Monomoy Islands (just off coast of Massachusetts)	C
Sei whale research (NEFSC)	NOAA ship *Henry B. Bigelow*	10 – 19 Jun	Georges Bank (east of Massachusetts) to Browns Bank (south of Nova Scotia)	D
Sea turtle tagging (NEFSC)	NOAA ship *Henry B. Bigelow*	23 Jun – 2 Jul	Southern Georges Bank to Canadian waters	E

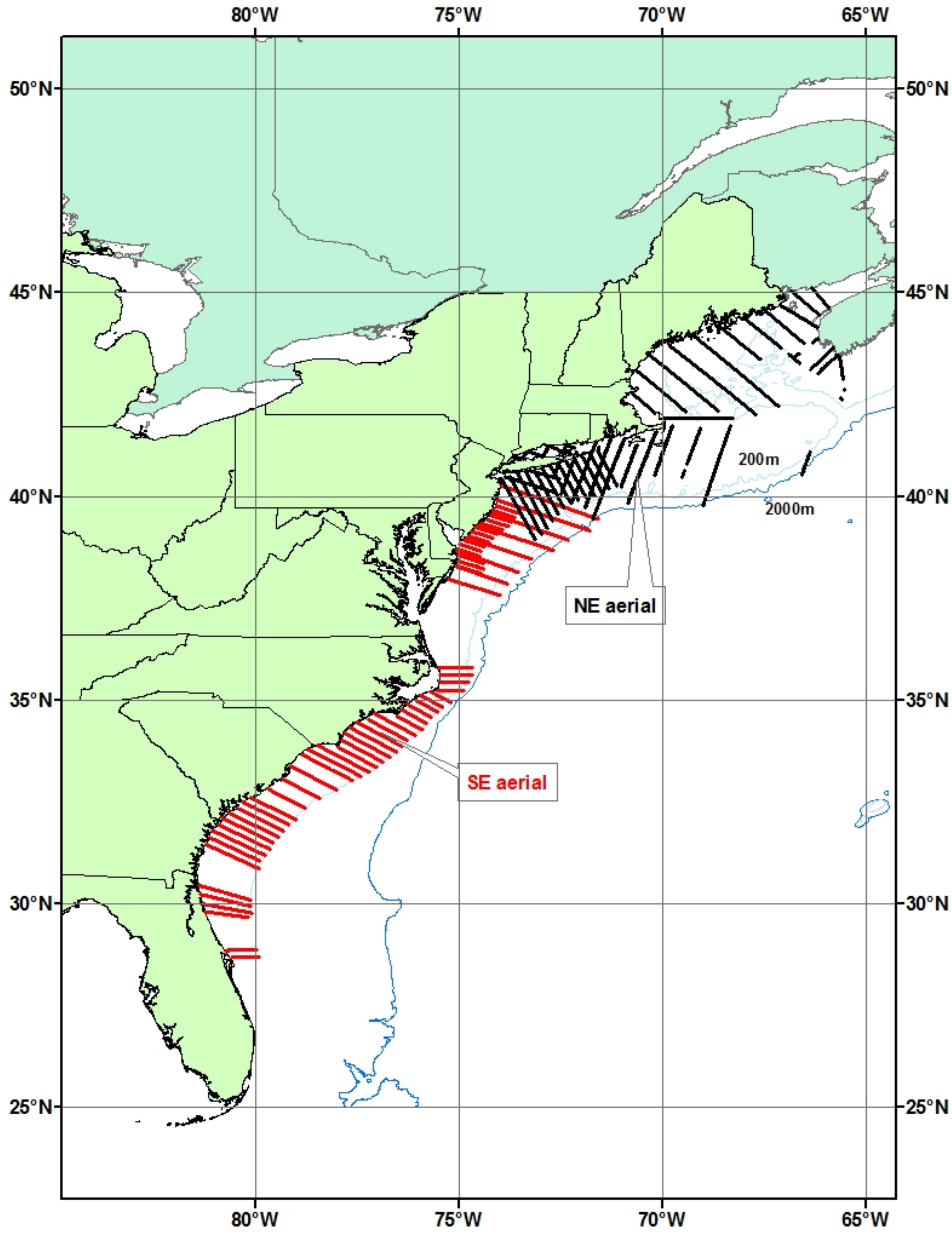
[1] Dates are in 2015 unless year is specified.

Table 2. A brief description of the purpose of the AMAPPS NOAA Fisheries Service analyses projects that occurred during 2015 and the appendix where more information can be found.

2015 analysis projects	Purpose	Appendix
Spatially- and temporally-explicit density models and maps	Develop Bayesian hierarchical and generalized additive models to quantify relationship between marine mammals and sea turtles and habitat	F
Availability estimates for cetaceans using DTAGs	Estimate dive patterns to estimate availability using data from DTAGs on a variety of cetaceans collected by other researchers	F
Assess accuracy of remote sensed data	Assess the accuracy of remotely-sensed environmental data values of several satellite-derived and HYCOM ocean model-variables as compared to in-situ values	F
e-Ranger development	Develop an electronic range finder that can be attached to big-eye binoculars to be used to determine the distance to an animal	F
Initiate the East Coast Migratory Corridor 2.0 project	Deploy 5 lines of MARUs along the continental shelf to monitor migratory timing and pathways of baleen whales.	G
Initiate the Shelf Break Acoustic Ecology project	Deploy 8 HARPs along the shelf break from Georges Bank to Blake Plateau to extend Migratory Corridor project to deeper waters and also to monitor other whales and dolphins	G
Acoustic and visual abundance estimate of sperm whales	Use the acoustic and visual detection rates collected in AMAPPS surveys to derive a more accurate abundance estimate of sperm whales	G
Beaked whale acoustics	Quantify acoustic detection rates of beaked whales, assess effect of echosounder use on beaked whale detections, and localize in 3-D the position of the beaked whales	G
Whistle and echolocation classification	Test the performance of the Atlantic version of the Real-time Odontocete Call Classification Algorithm (ROCCA)	G
Occurrence of baleen whales on Georges Bank	Use bottom-mounted recorders to document presence of baleen whale calls during Apr – Sep 2014	G
Geographic variation in echolocation clicks of Risso's dolphins	Characterize the spectral banding patterns of Risso's dolphins from around the world and determine if geographic differences indicate population structure	G
Process and compare EK60 active acoustic backscatter data	Process active acoustic backscatter data (represents middle level trophic level taxa) so they can be compared to distributions of marine mammals, sea turtles and sea birds	H

2015 analysis projects	Purpose	Appendix
Process and compare the Visual Plankton Recorder images	Process images of plankton from the Visual Plankton Recorder so they can be compared to distributions of marine mammals, sea turtles and sea birds	H
Process and compare the organisms in net tows	Enumerate samples from bongo nets, MOCNESS and midwater trawls so they can be compared to distributions of marine mammals, sea turtles and birds	H
Expand database to include new AMAPPS data	Build on the existing NEFSC Oracle databases to store and process data collected under the various AMAPPS projects	I
Display density maps and estimates of abundance	Build a web-based interactive interface to display the seasonal species density distribution maps and summarize density and abundance estimates for user-specified areas	I

Figure 1. Track lines completed during the December 2014 – April 2015 AMAPPS aerial surveys conducted by the Northeast and Southeast Fisheries Science Centers.



Appendix A: *Northern leg of aerial abundance survey during December 2014 – January 2015: Northeast Fisheries Science Center*

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SUMMARY

During 5 December 2014 – 14 January 2015, the Northeast Fisheries Science Center (NEFSC) conducted aerial abundance surveys targeting marine mammals and sea turtles. The southwestern extent was New Jersey and the northeastern extent was the southern tip of Nova Scotia, Canada. This survey covered waters from the coast line to about the 2000 m depth contour with a higher coverage over the New York State Offshore Planning Area. Track lines were flown 183 m (600 ft) above the water surface, at about 200 kph (110 knots). The two-independent team methodology was used to collect the data. In Beaufort sea states of six and less, about 5670 km of on-effort track lines were surveyed. About 1900 individuals within 84 groups of 17 species (or species groups) of live cetaceans, seals and large fish were detected by one or both teams. Short-beaked common dolphins (*Delphinus delphis*) were the most commonly detected species: including six groups that had more than 40 animals per group, of which one group had about 1200 individuals. The most common large whale was the right whale (*Eubalaena glacialis*), where 4 unique groups of 9 individuals were detected. One loggerhead turtle (*Caretta caretta*) was detected. In addition, harbor seals (*Phoca vitulina*), gray seals (*Halichaerus grypus*), basking sharks (*Cetorhinus maximus*) and ocean sunfish (*Mola mola*) were also detected.

OBJECTIVES

The objectives of these aerial flights were to collect the data needed to estimate abundance of cetaceans and turtles in the study area, and to investigate how the animal's distribution and abundance relate to their physical and biological ecosystem.

CRUISE PERIOD AND AREA

This survey was conducted during 5 December 2014 – 14 January 2015. The study area extended from New Jersey to the southern tip of Nova Scotia, Canada, from the coast line to about the 2000 m depth contour (Figure A1).

The proposed track lines cover the entire region using a broad scale strategy providing an overall spatial coverage. In addition, higher resolution track lines covered the New York State Offshore Planning Area (http://www.dos.ny.gov/opd/programs/offshoreResources/) providing higher coverage within this Area.

METHODS

The aerial surveys were conducted on a DeHavilland Twin Otter DHC-6 aircraft over Atlantic Ocean waters off the east coast of the U.S. and Canada. Track lines were flown 183 m (600 ft) above the water surface, at about 200 kph (110 knots), when Beaufort sea state conditions were six and below, and when there was at least two miles of visibility.

When a cetacean, seal, turtle, sunfish, or basking shark was observed the following data were collected:

- Time animal passed perpendicular to the observer;
- Species identification;
- Species identification confidence level (certain, probable, not sure);
- Best estimate of the group size;
- Angle of declination between the track line and location of the animal group when it passed abeam (measured to the nearest one degree by inclinometers or marks on the windows, where 0º is straight down);
- Cue (animal, splash, blow, footprint, birds, vessel/gear, windrows, disturbance, or other);
- Swim direction (0º indicates animal was swimming parallel to the track line in the same direction the plane was flying, 90º indicates animal was swimming perpendicular to the track line and towards the right, etc.);
- If the animal appeared to react to the plane (yes or no);
- If a turtle was initially detected above or below the surface, and;
- Comments, if any.

Other fish species were also recorded opportunistically. Species identifications were recorded to the lowest taxonomic level possible.

At the beginning of each leg, and when conditions changed the following effort data were collected:

- Initials of person in the pilot seats and observation stations;
- Beaufort sea state (recorded to one decimal place);
- Water turbidity (clear, moderately clear, turbid very turbid, and unknown);
- Percent cloud cover (0-100%);
- Angle glare swath started and ended at (0-359º), where 0º was the track line in the direction of flight and 90º was directly abeam to the right side of the track line;
- Magnitude of glare (none, slight, moderate, and excessive); and
- Subjective overall quality of viewing conditions (excellent, good, moderate, fair, and poor).

In addition, the location of the plane was recorded every two seconds with a GPS that was attached to the data entry program. Sightings and effort data were collected by a computer program called VOR.exe, version 8.75 originally created by Phil Lovell and Lex Hiby.

To help correct for perception bias, data were collected to estimate the parameter *g(0)*, the probability of detecting a group on the track line. This was accomplished by using the two independent team data collection method (Laake and Borchers 2004). In addition, the approximate area that a species can be detected was determined, when possible by the front team. This was accomplished by recording the time a group was initially seen and then also collected the time and angle of declination of that same group when it was perpendicular to the observers position. The initial time a group was seen was identified in the sightings data by a species identification of “FRST”.

Onboard, in addition to two pilots, were six scientists who were divided into two teams. One team, the primary forward team, consisted of a recorder and two observers viewing through the two forward right and left bubble windows. The other team, the independent back team, consisted of one observer viewing through the back belly window, one observer viewing from the right back visa window, and a recorder. The two observer teams operated on independent intercom channels so that they were not able to cue one another to sightings.

The belly window observer was limited to approximately a 30º view on both sides of the track line. The bubble window and back side visa window observers searched from straight down to the horizon, with a concentration on waters between straight down (0º) and about 50º up from straight down.

When at the end of track lines or about every 30-40 minutes, scientists rotated between the observations positions. When both teams could not identify the species of a group that was within about 60º of the track line and there was a high chance that the group could be relocated or the species was thought to have been a right whale then sighting effort was broke off, and the plane returned to the group to confirm the species identification and group size. The marine mammal and turtle data were reviewed after the flights to identify duplicate sightings that were made by the two teams based upon time, location, and position relative to the track line.

RESULTS

The observers and pilots who collected these data are listed in Table A1.

Fourteen of the 39 days had sufficiently good weather and a working plane to conduct the survey. There were about 5670 km of "on-effort" track lines, where 72% of the track lines were surveyed in Beaufort 2 and 3 (Table A2).

On the on-effort portions of the track lines, 1569 and 517 individual cetaceans within 34 and 36 groups were detected by the back and front teams, respectively (Table A3). The locations of sightings seen on the on-effort transect legs, by species, are displayed in Figures A2 – A5, where dolphins are in Figure A2 – A3, whales in Figures A4, while seals, turtles and other species are in Figure A5. The sightings included nine species of identifiable cetaceans: common bottlenose dolphins (*Tursiops truncatus*), short-beaked common dolphins, striped dolphins (*Stenella coeruleoalba*), Risso's dolphins (*Grampus griseus*), white-sided dolphins (*Lagenorhynchus acutus*), harbor porpoise (*Phocoena phocoena*), fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*) and right whales. In addition, one loggerhead and one dead turtle were seen; harbor and gray seals, along with basking sharks and ocean sunfish were also detected.

Short-beaked common dolphins were the most commonly detected species: including six groups that had more than 40 animals per group, of which one group had about 1200 individuals. The most common large whale was the right whale, where 4 unique groups of 9 individuals were detected. Harbor and gray seals were only seen close to shore, while basking sharks and ocean sunfish were in deeper offshore waters.

DISPOSITION OF DATA

All data collected during this survey will be maintained by the Protected Species Branch at NEFSC in Woods Hole, MA and are available from the NEFSC's Oracle database. The line transect data are available on OBIS-SEAMAP.

PERMITS

NEFSC was authorized to conduct these research activities during this survey under US Permit No. 17355 issued to the NEFSC by the NMFS Office of Protected Resources. The NOAA aircraft was granted diplomatic overflight clearance in Canadian airspace with the Overflight

Clearance number 0790-US-2014-12. The Species at Risk Management Division of the Canadian Fisheries and Oceans concluded a permit under SARA was not needed.

ACKNOWLEDGEMENTS

Funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements for the AMAPPS project. Flight time and other aircraft costs were funded by NOAA Aircraft Operations Center (AOC). Staff time was also provided by the NOAA Fisheries Service, NEFSC and NOAA AOC. We would like to thank the pilots and observers involved in collecting these data for their efforts and dedication to this project.

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Laake JL, Borchers DL. 2004. Methods for incomplete detection at distance zero, In: Advanced distance sampling, edited by S. T. Buckland, D. R. Andersen, K. P. Burnham, J. L. Laake, and L. Thomas, pp. 108–189, Oxford University Press, New York.

Table A1. List of observers and pilots, along with their affiliations, that participated in the winter 2014/15 Northeast AMAPPS aerial survey.

Name	Affiliation
OBSERVERS	
Allison Chaillet	Integrated Statistics, Inc, Woods Hole, MA
Leah Crowe	Integrated Statistics, Inc, Woods Hole, MA
Robert DiGiovanni	Integrated Statistics, Inc, Woods Hole, MA
Marjorie Foster	Integrated Statistics, Inc, Woods Hole, MA
Rachel Hardee	Integrated Statistics, Inc, Woods Hole, MA
Richard Holt	Integrated Statistics, Inc, Woods Hole, MA
Val Sherlock	Integrated Statistics, Inc, Woods Hole, MA
PILOTS	
Kevin Doremus	NOAA Aircraft Operations Center, Tampa, FL
Kerryn Schneider	NOAA Aircraft Operations Center, Tampa, FL
Mattrew Nardi	NOAA Aircraft Operations Center, Tampa, FL
Phillip Eastman	NOAA Aircraft Operations Center, Tampa, FL

Table A2. Length of on-effort track lines (in km) surveyed by Beaufort sea state.

	Beaufort sea state						
	1	2	3	4	5	6	Total
track length (km)	213.6	1272.7	2817.5	1026.1	310.4	30.6	5670.9
% of total	4	22	50	18	5	1	100

Table A3. Winter 2014/15 Northeast AMAPPS aerial survey: Number of groups and individuals of species detected while on-effort by the front and back teams. Some of the groups seen by the back team were also seen by the front team.

		Number of groups		Number of individuals	
Species		**Back**	**Front**	**Back**	**Front**
Common bottlenose dolphin	*Tursiops truncatus*	1	1	9	4
Short-beaked common dolphin	*Delphinus delphis*	19	18	1511	420
Common or white-sided dolphin	-	0	4	0	7
Striped dolphin	*Stenella coeruleoalba*	7	2	36	29
Risso's dolphin	*Grampus griseus*	0	1	0	10
White-sided dolphin	*Lagenorhynchus acutus*	0	1	0	30
Harbor porpoise	*Phocoena phocoena*	0	1	0	3
Fin whale	*Balaenoptera physalus*	1	0	1	0
Humpback whale	*Megaptera novaeangliae*	2	2	2	2
North Atlantic right whale	*Eubalaena glacialis*	1	4	2	9
Unid dolphin	*Delphinidae*	1	1	6	2
Unid large whale	*Mysticeti*	2	1	2	1
Total cetaceans		34	36	1569	517
Loggerhead turtle	*Caretta caretta*	1	1	1	1
dead turtle	-	0	1	0	1
Basking shark	*Cetorhinus maximus*	5	2	5	2
Ocean sunfish	*Mola mola*	2	1	2	1
Harbor seal	*Phoca vitulina*	0	1	0	1
Gray seal	*Halichoerus grypus*	5	3	6	5
Unid seal	*Pinnipedia*	4	2	4	36
Total all species		51	47	1587	564

Figure A1. Winter 2014/15 Northeast AMAPPS aerial survey (5 December 2014 – 14 January 2015): completed on-effort track lines by Beaufort sea state. The 100 m, 1000 m and 2000 m depth contours (colored dotted lines) and the New York State Offshore Planning Area (gray shading) are shown.

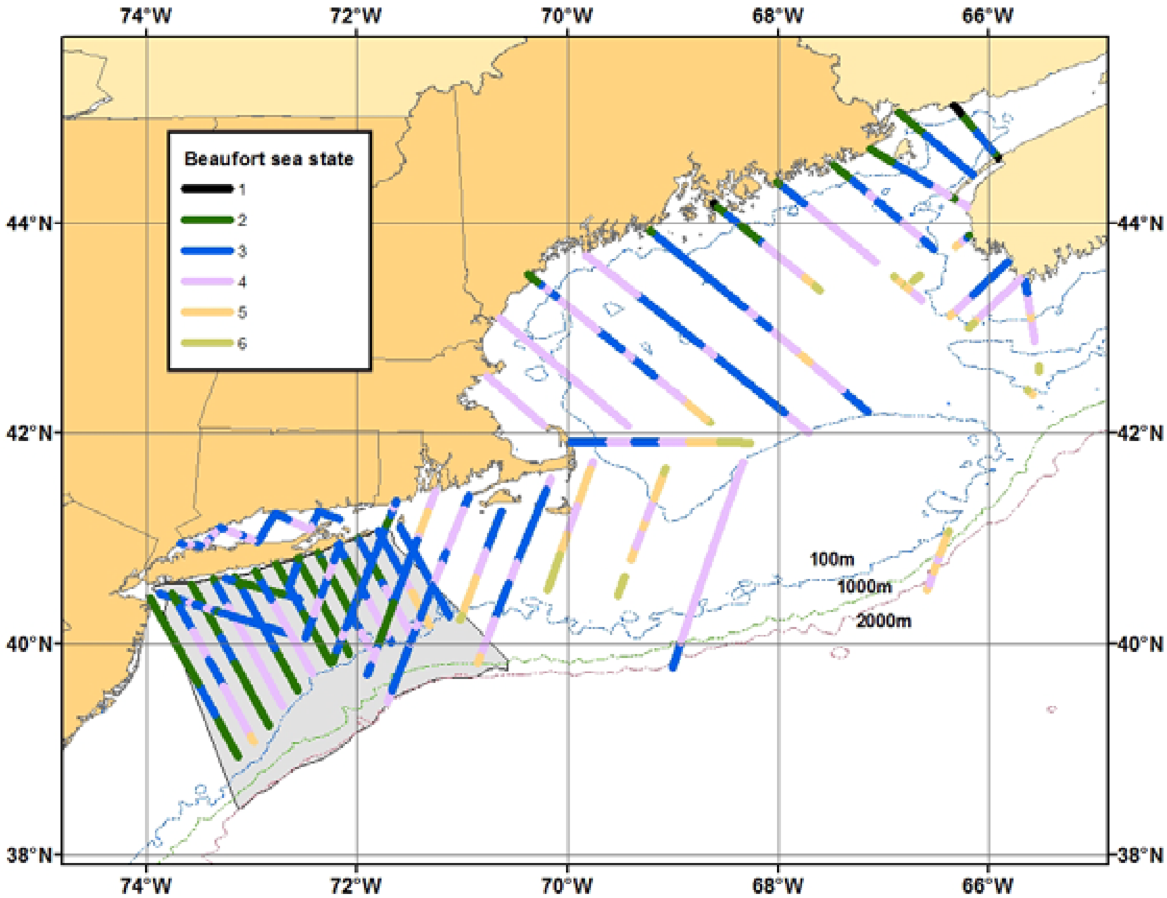


Figure A2. Winter 2014/15 Northeast AMAPPS aerial survey (5 December 2014 – 14 January 2015): Locations of short-beaked common (*Delphinus delphis*) and white-sided dolphins (*Lagenorhynchus acutus*) detected by one or both of the teams. The 100 m, 1000 m and 2000 m depth contours (colored dotted lines) and the New York State Offshore Planning Area (gray shading) are shown.

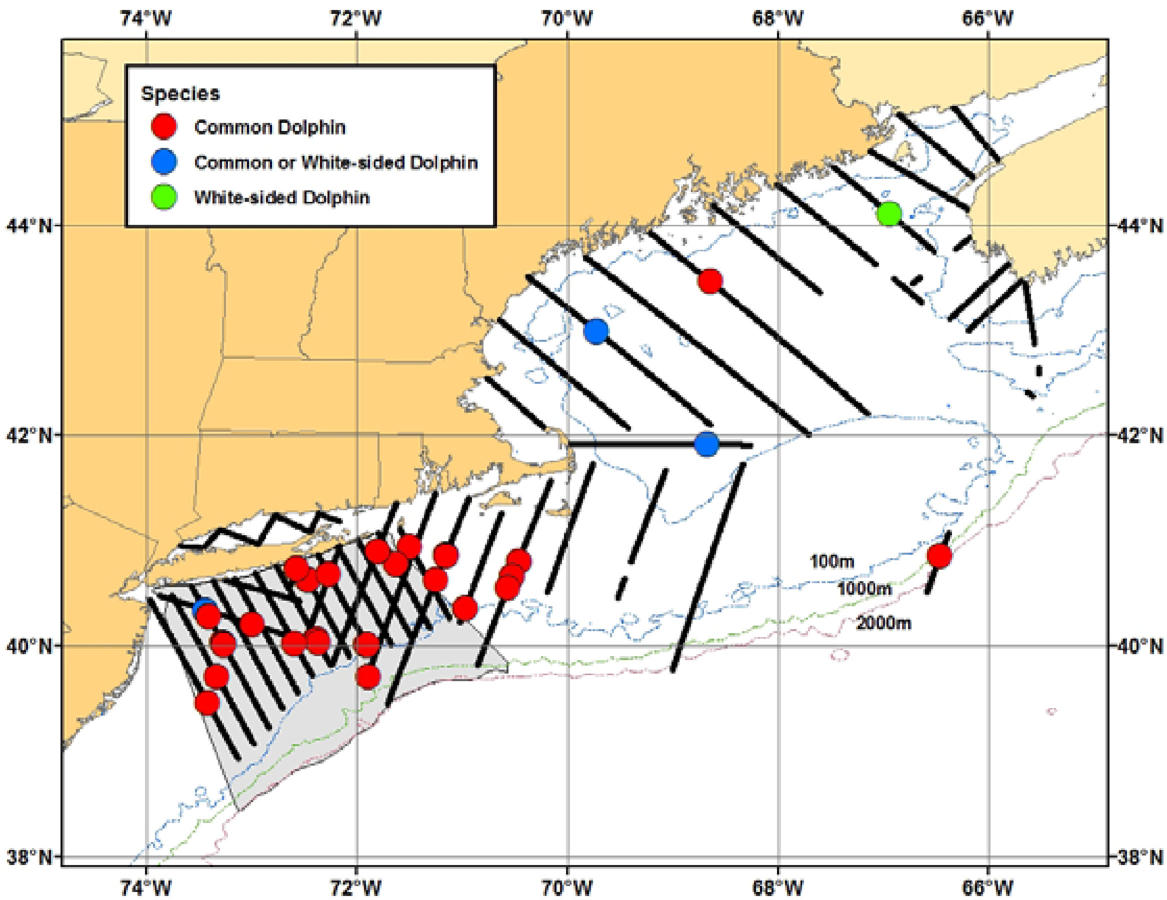


Figure A3. Winter 2014/15 Northeast AMAPPS aerial survey (5 December 2014 – 14 January 2015): Locations of common bottlenose dolphins (*Tursiops truncatus*), harbor porpoises (*Phocoena phocoena*), Risso's dolphins (*Grampus griseus*), striped dolphins (*Stenella coeruleoalba*) and unidentified dolphins detected by one or both of the teams. The 100 m, 1000 m and 2000 m depth contours (colored dotted lines) and the New York State Offshore Planning Area (gray shading) are shown.

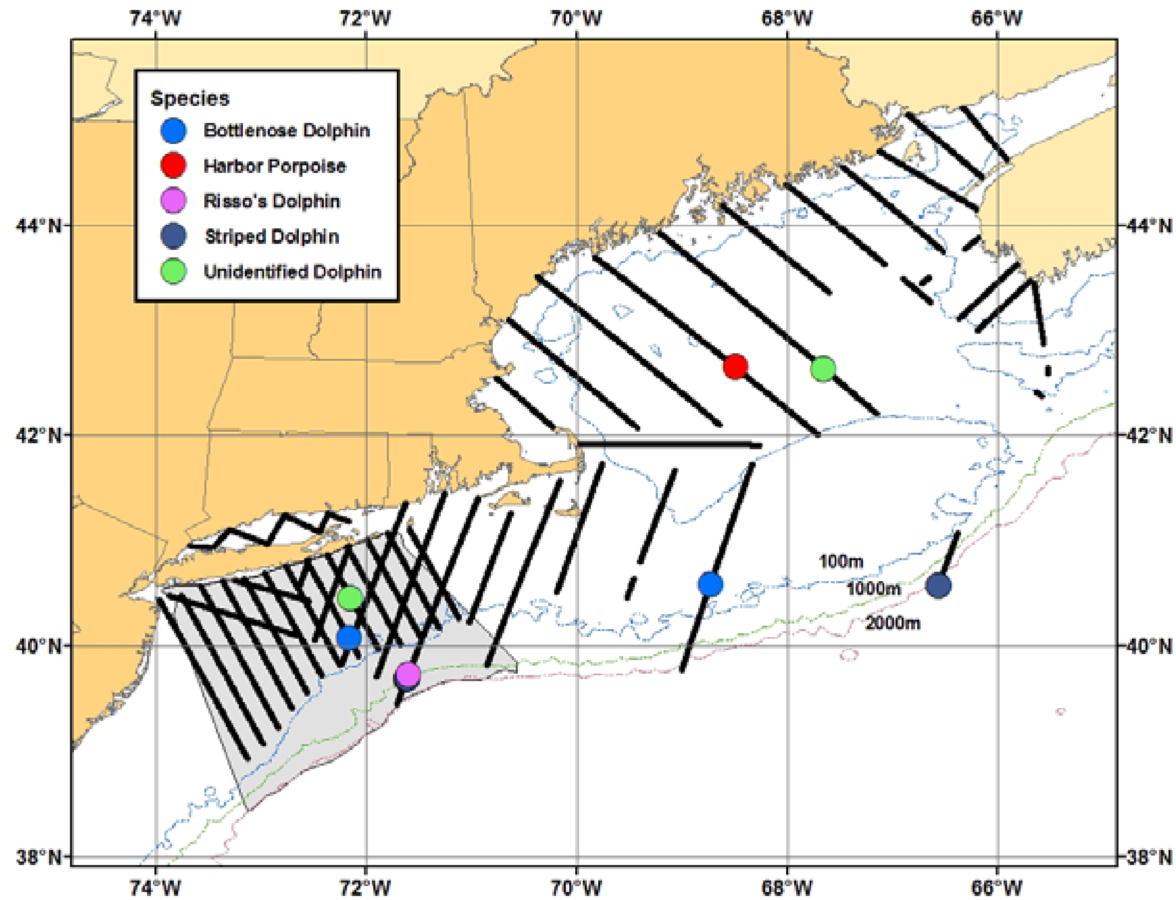


Figure A4. Winter 2014/15 Northeast AMAPPS aerial survey (5 December 2014 – 14 January 2015): Locations of fin (*Balaenoptera physalus*), humpback (*Megaptera novaeangliae*), North Atlantic right (*Eubalaena glacialis*) and unidentified whales detected by one or both of the teams. The 100 m, 1000 m and 2000 m depth contours (colored dotted lines) and the New York State Offshore Planning Area (gray shading) are shown.

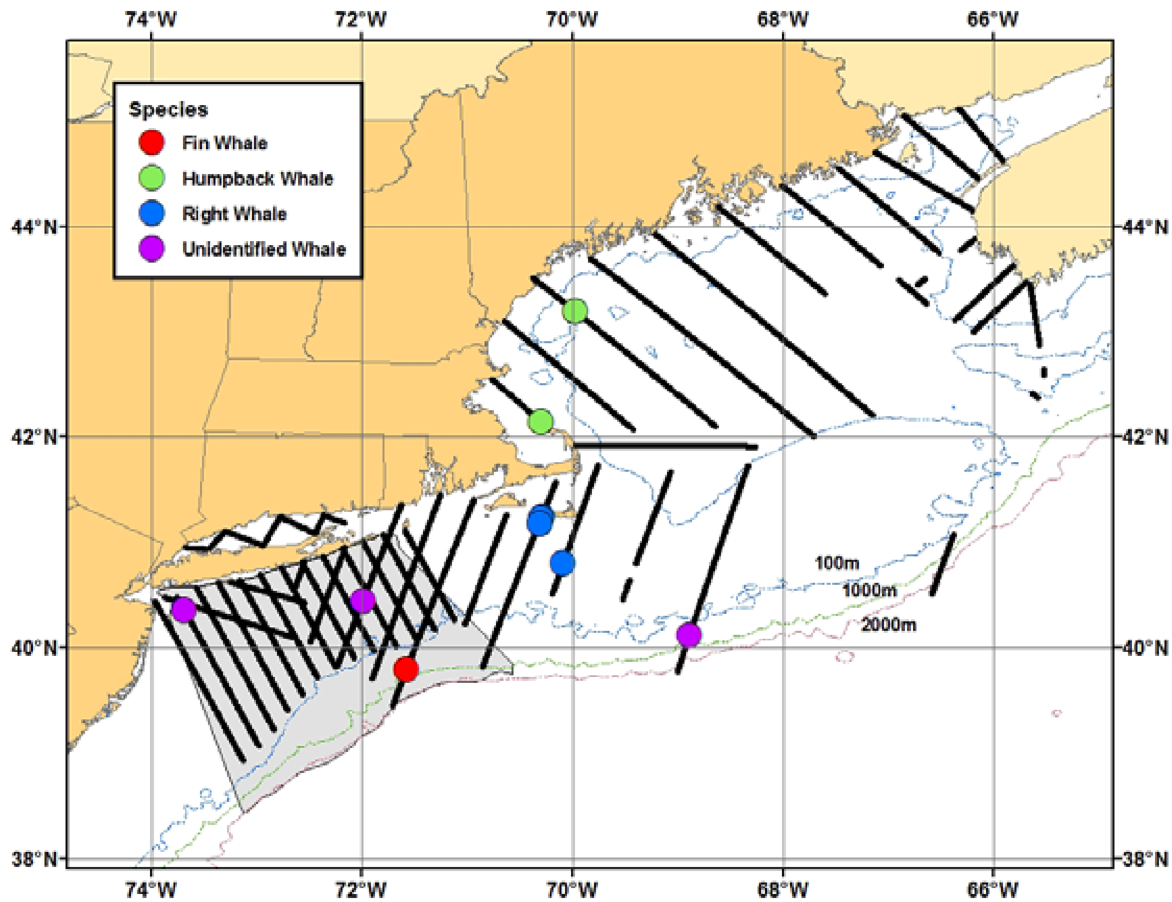
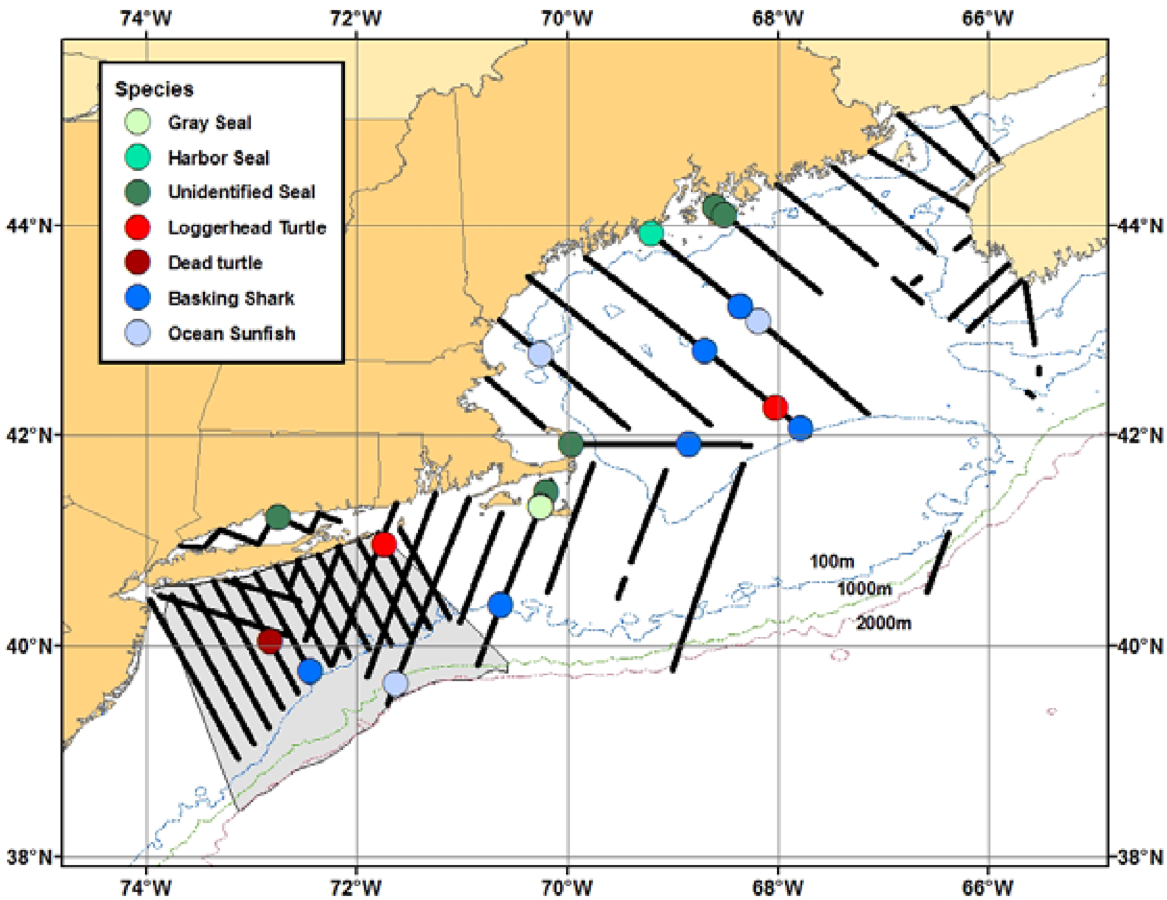


Figure A5. Winter 2014/15 Northeast AMAPPS aerial survey (5 December 2014 – 14 January 2015): Locations of gray (*Halichoerus grypus*), harbor (*Phoca vitulina*) and unidentified seals, loggerhead turtles (*Caretta caretta*), a dead turtle, basking sharks (*Cetorhinus maximus*), and ocean sunfish (*Mola mola*) that were detected by one or both of the teams. The 100 m, 1000 m and 2000 m depth contours (colored dotted lines) and the New York State Offshore Planning Area (gray shading) are shown.



Appendix B: *Southern leg of aerial abundance survey during January - March 2015: Southeast Fisheries Science Center*

Lance P. Garrison[1], Kevin P. Barry[2]

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SUMMARY

As part of the AMAPPS program, the Southeast Fisheries Science Center conducts aerial surveys of continental shelf waters along the US east coast from Cape Canaveral, Florida to Cape May, New Jersey. The survey was conducted during 2015 between 23 January and 3 March. It was conducted along tracklines oriented perpendicular to the shoreline that were latitudinally spaced 20 km apart aboard a NOAA Twin Otter aircraft at an altitude of 600 feet (183 m) and a speed of 110 knots. The survey was designed for analysis using Distance sampling and a two-team (independent observer) approach to correct for visibility bias in resulting abundance estimates. The survey covered waters from Cape May, NJ to Cape Canaveral, FL including "fine-scale" tracklines in waters offshore of New Jersey. The majority of survey effort occurred in waters from Cape Hatteras, NC and south. A total of 6,279 km of trackline were surveyed on-effort. Nine species of marine mammals were identified, with the majority being common bottlenose dolphins (*Tursiops truncatus*: 73 groups sighted totaling 700 animals) and short-beaked common dolphins (*Delphinus delphis*; 18 groups totaling 1071 animals). Three species of sea turtles were identified, with the majority of identified animals being loggerhead turtles (*Caretta caretta*: 196 sightings totaling 278 animals). The data collected from this survey will be analyzed to estimate the abundance and spatial distribution of mammals and turtles along the US east coast.

OBJECTIVES

The goal of the survey was to conduct line-transect surveys using the Distance sampling approach to estimate the abundance and spatial distribution of marine mammals and turtles in waters over the continental shelf (shoreline to 200m isobaths) from Southeast, Florida to Cape May, New Jersey. Due to weather conditions during the survey, only effort from Cape Canaveral, FL to Cape May, New Jersey was completed.

CRUISE PERIOD AND AREA

This survey was conducted during 23 January – 3 March 2015. The study area extended from Cape May, New Jersey to Cape Canaveral, Florida, from the coast line to about the 200 m depth contour (Figure B1).

METHODS

The survey was conducted aboard a DeHavilland Twin Otter DHC-6 flying at an altitude of 183m (600 ft) above the water surface and a speed of approximately 200 kph (110 knots). Surveys were typically flown only when wind speeds were less than 20 knots or approximately sea state 4 or less on the Beaufort scale. The survey was conducted along tracklines oriented perpendicular to the shoreline and spaced latitudinally at approximately 20 km intervals from a random start point (Figure B1). Offshore New Jersey within designated "Wind Areas", fine-scale tracklines were flown that were spaced 5 km apart.

There were two pilots and six scientists onboard the airplane. The scientists operated as two teams to implement the independent observer approach to correct for visibility bias (Laake and Borchers 2004). The forward team (Team 1) consisted of two observers stationed in bubble windows on either side of the airplane and an associated data recorder. The bubble windows allowed downward visibility including the trackline. The aft team (Team 2) consisted of a belly observer looking straight down through a belly port, an observer stationed on one side of the aircraft observing through a large window, and a dedicated data recorder. The side bubble window observer was stationed in a large "vista" window that provided trackline visibility while the belly observer can see approximately 35 degrees on either side of the trackline. Therefore, the aft team has limited visibility of the left side of the aircraft. The two observer teams operated on independent intercom channels so that they were not able to cue one another to sightings.

Data were entered by each team's data recorded onto a laptop computer running data acquisition software that recorded GPS location, environmental conditions entered by the observer team (e.g., sea state, water color, glare, sun penetration, visibility, etc.) and effort information.

During on effort periods (e.g., level flight at survey altitude and speed), observers searched visually from the trackline (0˚) to approximately 50˚ above vertical. When a turtle, mammal, or other organism was observed, the observer waited until it was perpendicular to the aircraft and then measured the angle to the organism (or the center of the group) using a digital inclinometer or recorded the angle in 10˚ intervals based upon markings on the windows. The belly observer only reported the interval for the sighting. Fish species were recorded opportunistically.

Sea turtle sightings were recorded independently, without communication, by each team. For marine mammal sightings, if the sighting was made initially by the forward team, they waited until it was aft of the airplane to allow the aft team an opportunity to observe the group before notifying the pilots to circle over the group. Once both teams had the opportunity to observe the group, the observers asked the pilots to break effort and circle the group. The aircraft circled over the majority of the marine mammal groups sighted to verify species identification and group sizes and to take photographs. The data recorders indicated at the time of the sighting whether or not the group was recorded by one or both teams.

Post survey, the turtle data were reviewed to identify duplicate sightings by the two teams based upon time, location, and position relative to the trackline.

RESULTS

The survey was conducted during 23 January – 3 March 2015, but survey flights could only be conducted on 13 days during that period due to weather conditions, mechanical issues, or transits between cities. A total of 6,279 km of trackline were covered on effort along 60 tracklines (Figure B1, Table B1). Survey effort was planned to cover waters as far south as Florida, but weather only allowed lines between South Carolina and Cape May, NJ to be completed. The average sea state during the survey was 2.7 on the Beaufort scale with the majority of the survey effort flown in sea states of 2 or 3 (Figure B2). However, some sections of trackline, particularly the outer portion of tracklines, were flown in sea states as high as six.

There were a total of 332 unique sightings of sea turtles for a total of 458 individuals. Turtles were identified as loggerhead turtles, leatherback turtles (*Dermochelys coriacea*), Kemp's ridley (*Lepidochelys kempii*) and unidentified hardshells (Table B2). Of these, the majority of identified turtle sightings were loggerhead turtles (Figure B3). Turtle sightings were restricted to the area south of Cape Hatteras, NC (Figure B3 – B4).

There were a total of 133 groups of marine mammals sighted for a total of 2,237 individuals. The primary species observed was common bottlenose dolphins; however, there were also 1,071 individual short-beaked common dolphins observed in 18 sightings. Large whales including North Atlantic right whales (*Eubalaena glacialis*), common minke whales (*Balaenoptera acutorostrata*) and fin whales (*B. physalus*) were seen in the northern portion of the survey area (Table B3, Figures B5 – B7).

Fish species sighted included primarily hammerhead sharks (*Sphyrnidae* spp.), rays, and ocean sunfish (*Mola mola*) (Figure B8).

DISPOSITION OF DATA

All data collected during the aerial survey are archived and managed at the Southeast Fisheries Science Center, Miami, FL. The final clean version is also archived in the Northeast Fisheries Science Center ORACLE database. The line transect data are available online on OBIS-SEAMAP.

PERMITS

The SEFSC was authorized to conduct marine mammal research activities during the cruise under Permit No. 779-1633-02 issued to the SEFSC by the NMFS Office of Protected Resources.

ACKNOWLEDGEMENTS

The funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements for the AMAPPS project. Flight time and other aircraft costs were funded by NOAA Aircraft Operations Center. Staff time was provided by the NOAA Fisheries Service, Southeast Fisheries Science Center and NOAA Aircraft Operations Center. We would also like to thank the airplane's crew and observers that were involved in collecting these data.

REFERENCES CITED

Laake, J.L. and Borchers, D.L. 2004. Methods for incomplete detection at distance zero. In: Advanced Distance Sampling. Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., and Thomas, L. (eds.). Oxford University Press, 411 pp.

Table B1. Daily summary of survey effort and protected species sightings during Southeast AMAPPS Winter/Spring 2015 aerial survey.

Date	Effort (km)	Marine Mammal Sightings	Turtle Sightings	Average Sea State
1/23/2015	792.3	7	0	2.7
1/29/2015	918.5	10	0	2.5
2/1/2015	334.3	4	0	2.7
2/12/2015	454.9	7	12	4.6
2/13/2015	514.4	15	7	3.1
2/14/2015	268.0	19	18	2.9
2/16/2015	849.4	18	62	3.2
2/20/2015	554.0	4	28	2.9
2/22/2015	509.0	12	13	3.0
2/25/2015	447.0	4	19	2.7
2/26/2015	145.6	1	7	3.6
3/2/2015	22.1	1	1	1.8
3/3/2015	470.0	31	291	1.7
Total	**6,279**	**133**	**458**	**2.9**

Table B2. Summary of sea turtle sightings during Southeast AMAPPS Winter/Spring 2015 aerial survey.

Species	Number of sightings	Number of animals
Unid. Hardshell	106	140
Leatherback	12	12
Loggerhead	196	278
Kemp's Ridley	18	28
Total	**332**	**458**

Table B3. Summary of marine mammal sightings during Southeast AMAPPS Winter/Spring 2015 aerial survey.

Species	Number of groups	Number of animals
Atlantic spotted dolphin	18	232
Bottlenose Dolphin	73	700
Bottlenose/Atl Spotted Dolphin	7	99
Common Dolphin	18	1071
Cuvier's Beaked Whale	1	1
Fin Whale	1	1
Minke Whale	1	1
North Atlantic Right Whale	1	2
Pilot Whales	1	6
Risso's Dolphin	3	45
Stenella sp.	1	40
Unid. Baleen whale	1	2
Unid. Dolphin	7	37
Total	**133**	**2,237**

Figure B1. Aerial survey tracklines during the Southeast AMAPPS Winter/Spring 2015 aerial survey.

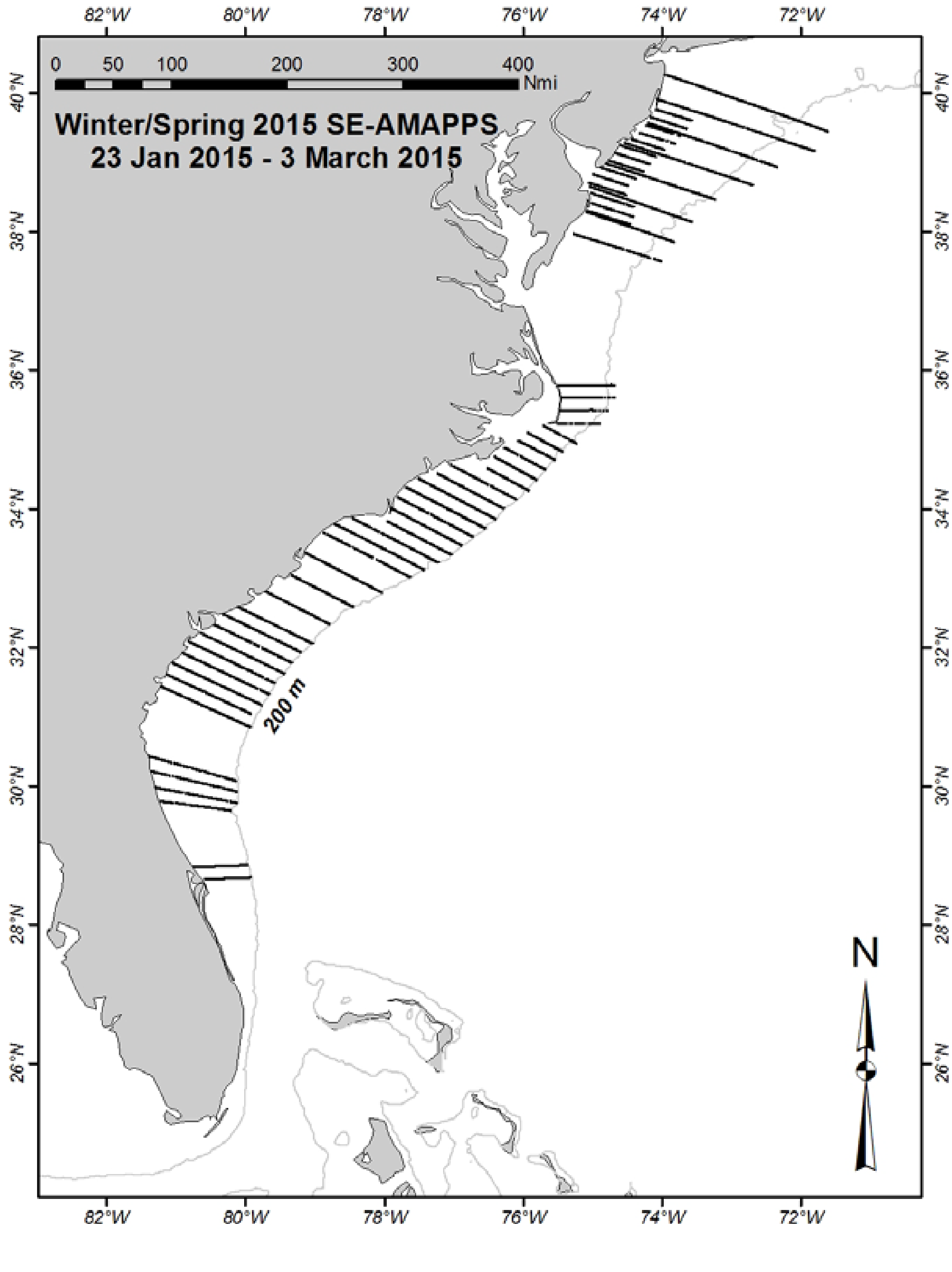


Figure B2. Beaufort sea states during the Southeast AMAPPS Winter/Spring 2015 aerial survey.

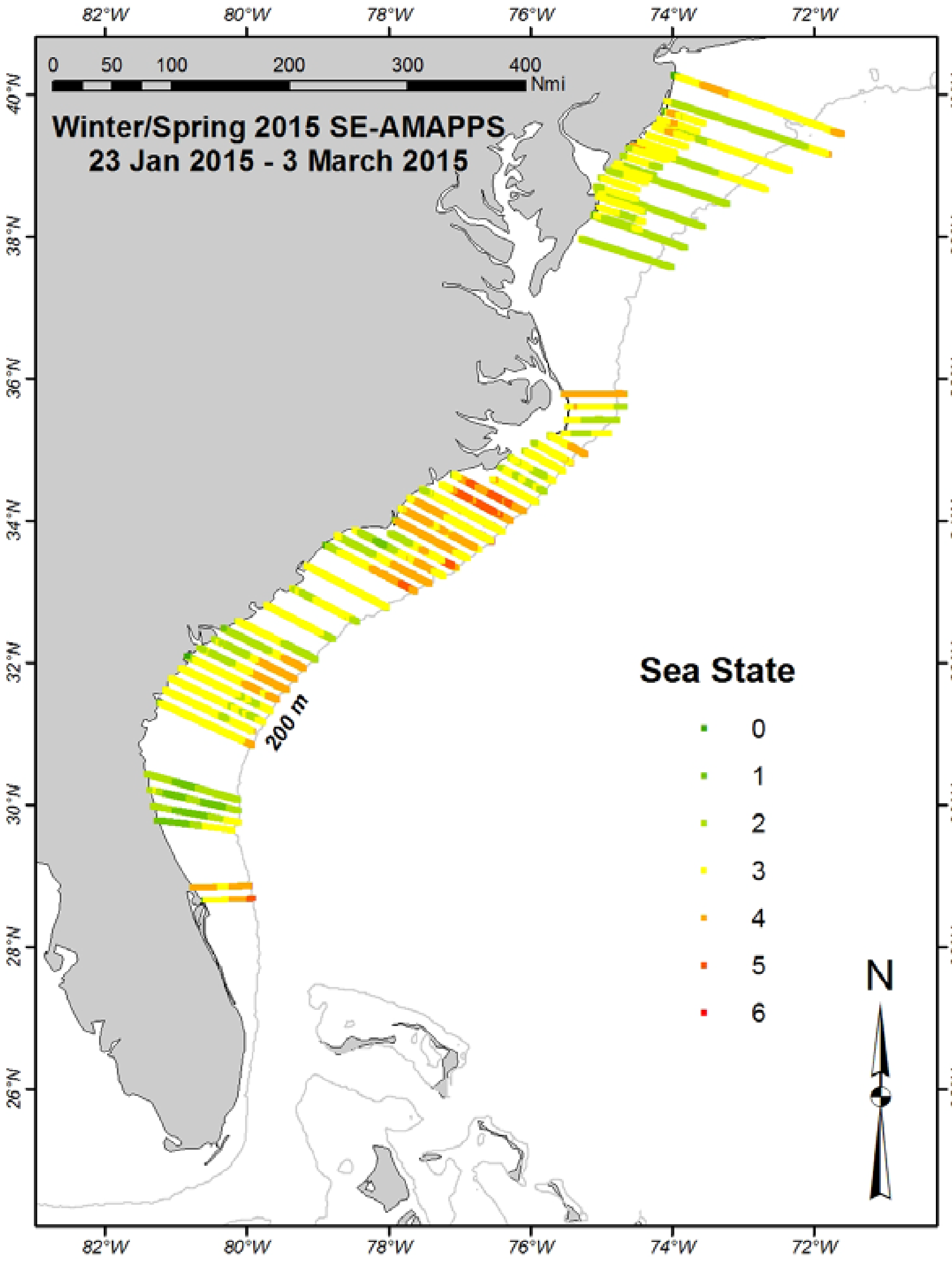


Figure B3. Loggerhead turtle (*Caretta caretta*) sightings during the Southeast AMAPPS Winter/Spring 2015 aerial survey.

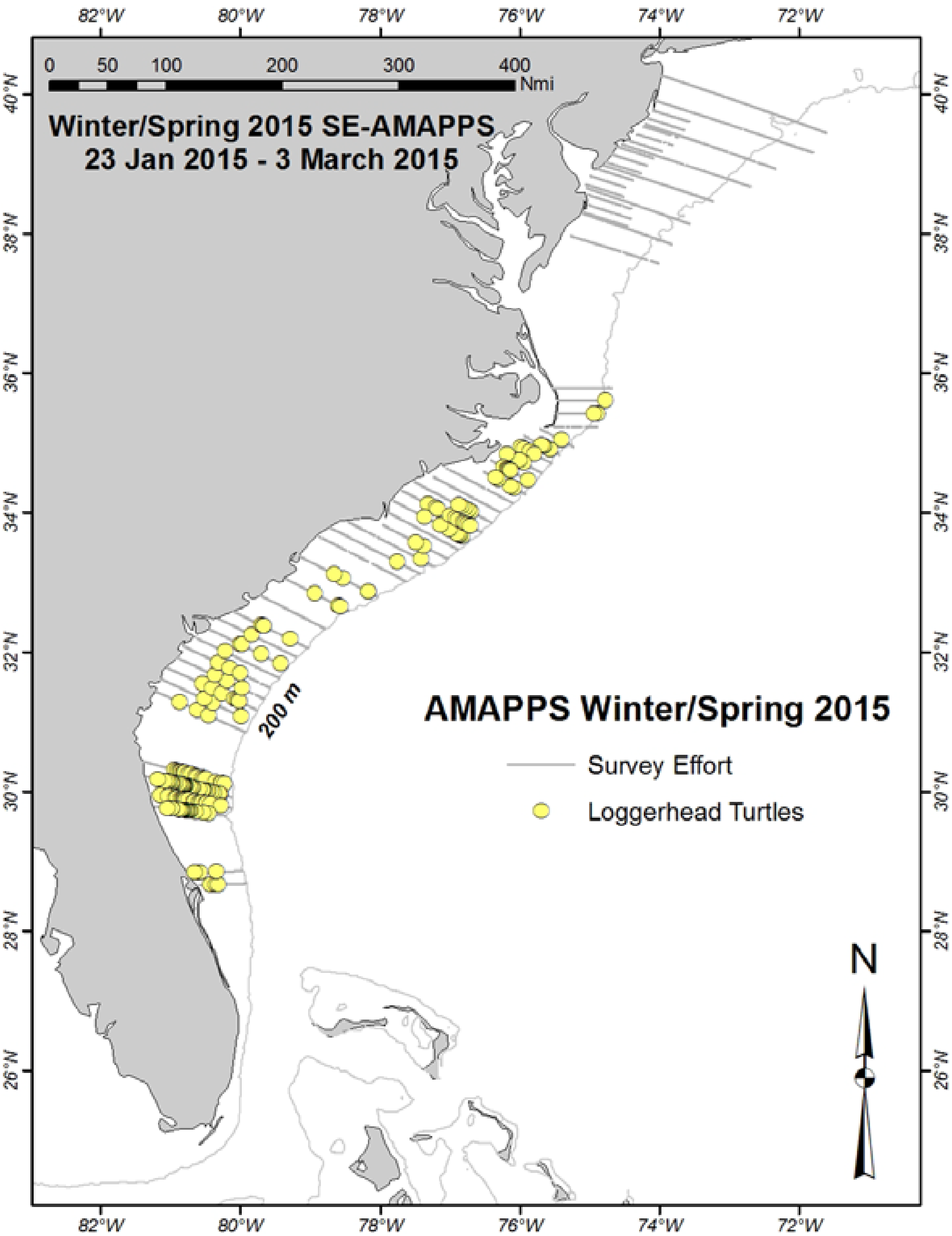


Figure B4. Other turtle sightings during the Southeast AMAPPS Winter/Spring 2015 aerial survey.

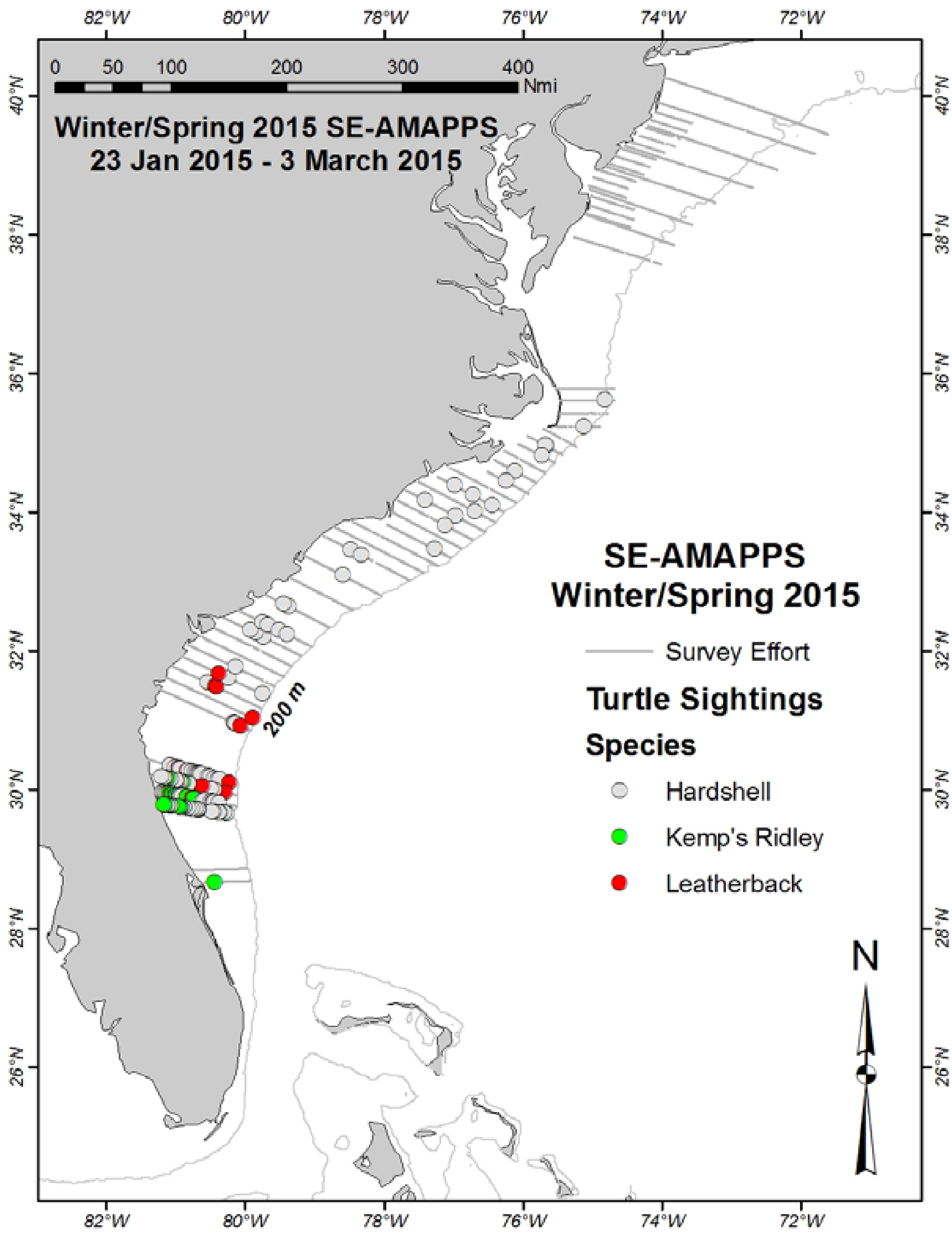


Figure B5. Common bottlenose dolphin (*Tursiops truncatus*) sightings during the Southeast AMAPPS Winter/Spring 2015 aerial survey.

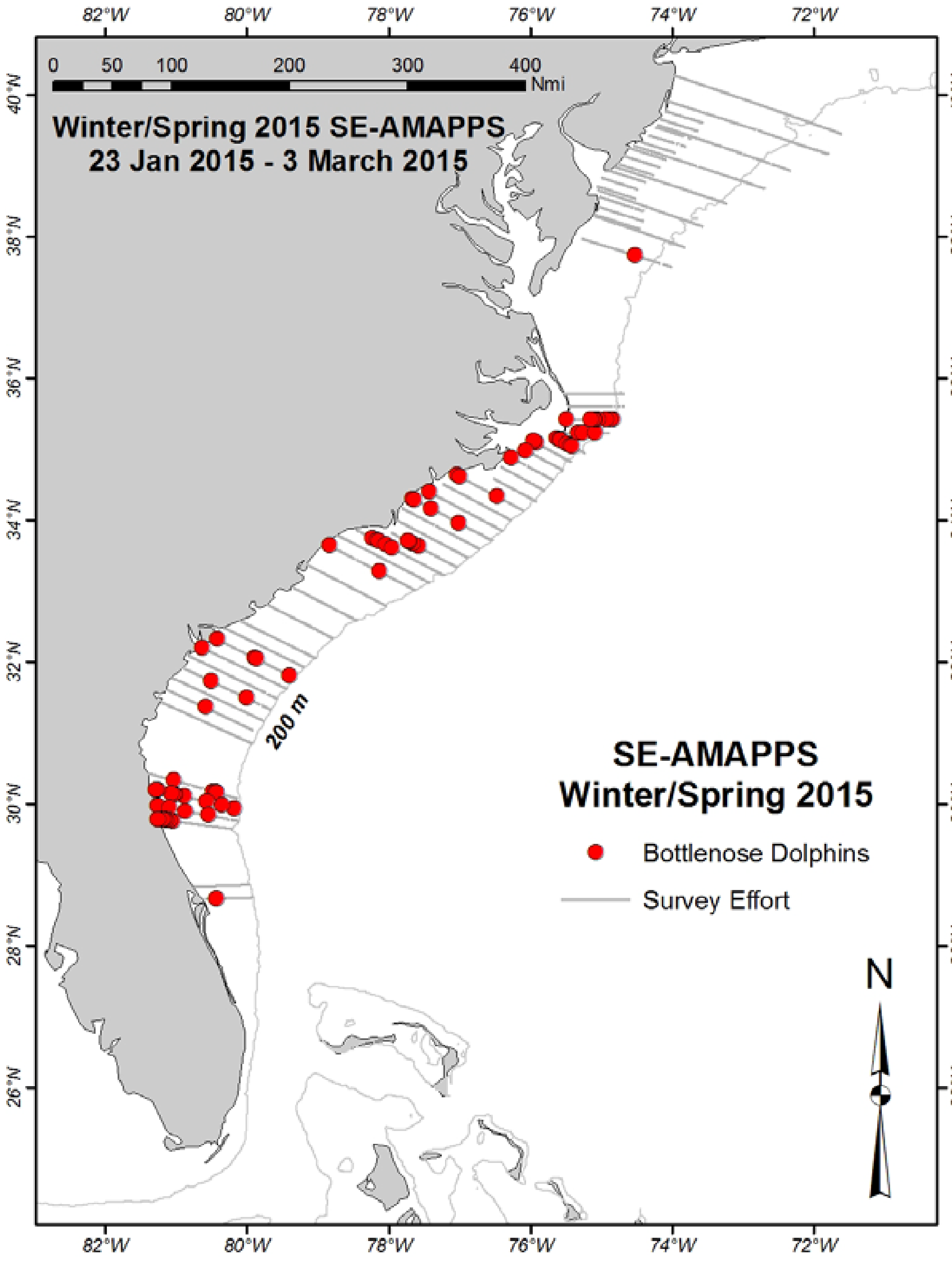


Figure B6. Other dolphin sightings during the Southeast AMAPPS Winter/Spring 2015 aerial survey.

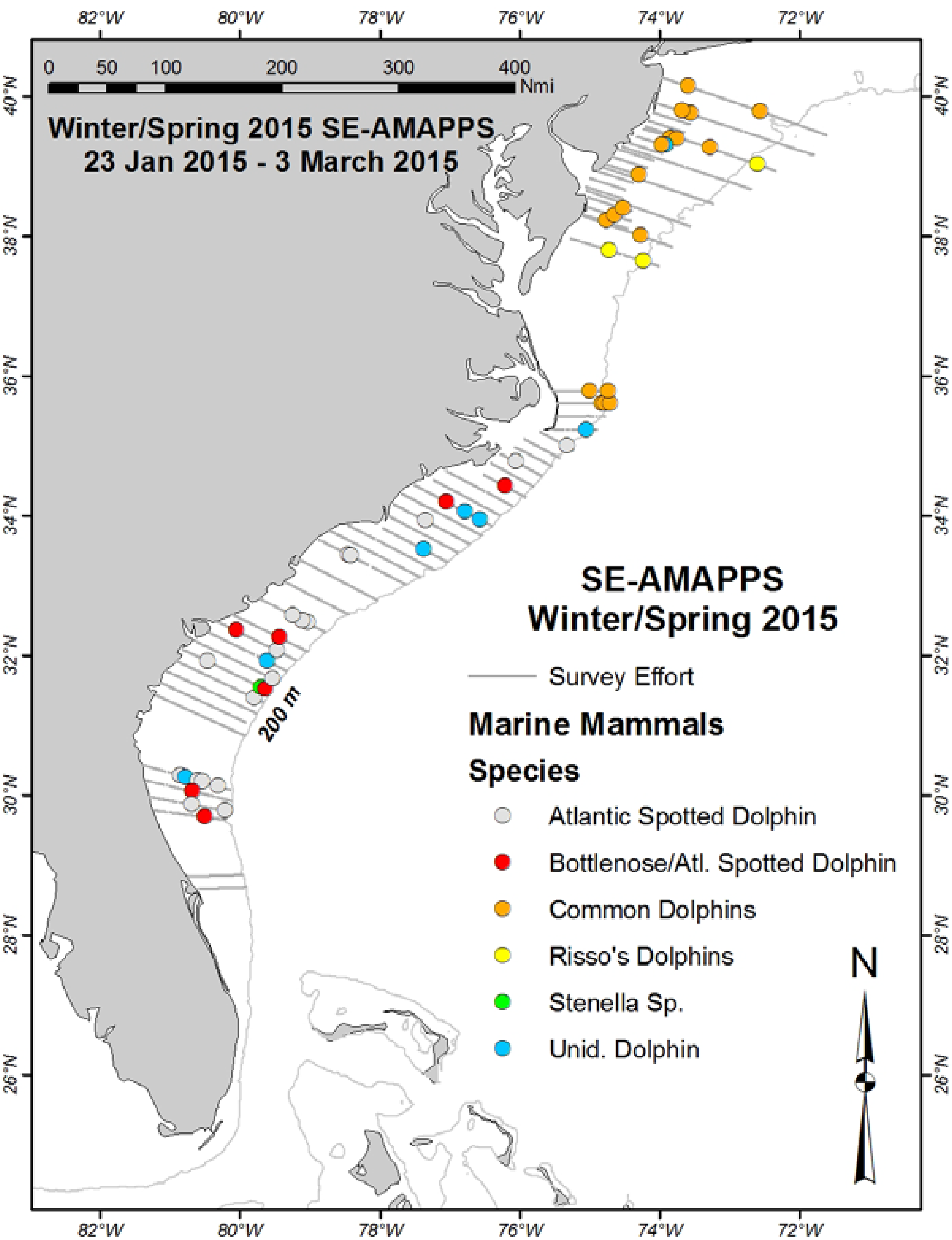


Figure B7. Whale sightings during the Southeast AMAPPS Winter/Spring 2015 aerial survey.

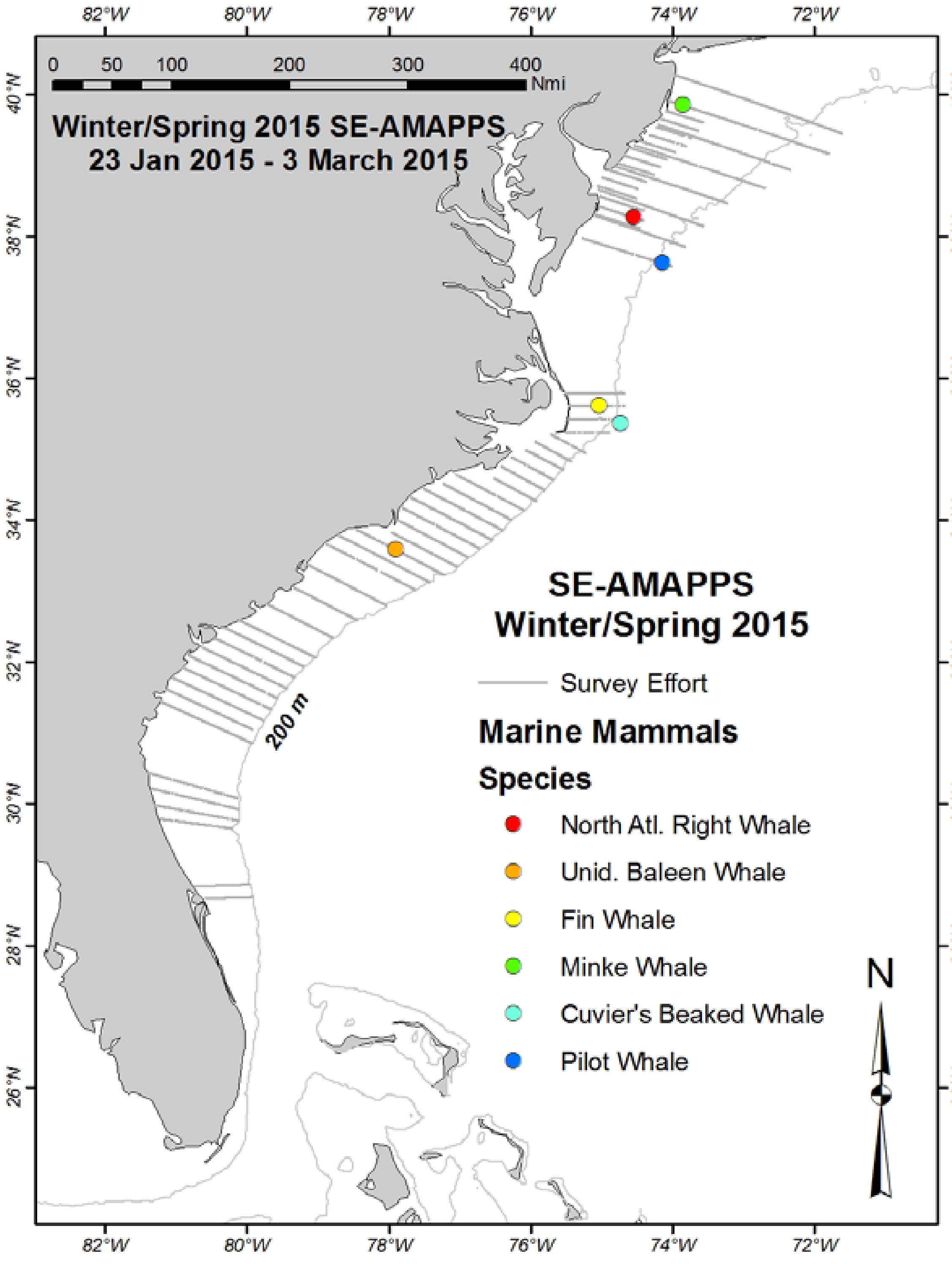
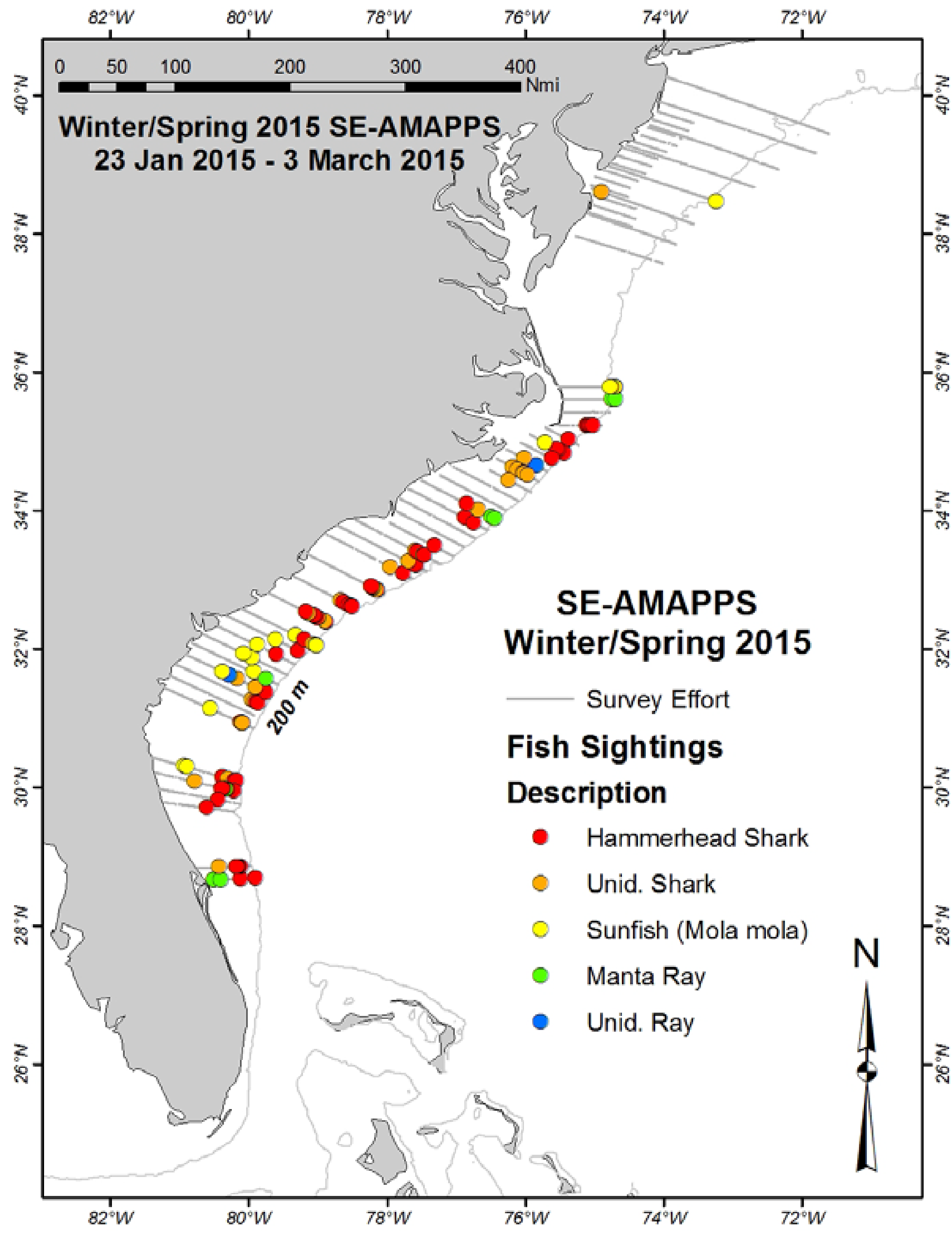


Figure B8. Fish sightings during the Southeast AMAPPS Winter/Spring 2015 aerial survey.



Appendix C: *Gray seal live capture, biological sampling, and tagging on Monomoy National Wildlife Refuge and Muskeget Island, January 2015: Northeast Fisheries Science Center*

Elizabeth Josephson[1], Wendy Blay Puryear[2], Mandy Keogh[2], Gordon T. Waring[3]

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[2] Massachusetts Institute of Technology, 77 Mass Ave, 16-719 Cambridge, MA 02139
[3] Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543, retired

SUMMARY

One fully-molted female gray seal (*Halichoerus grypus grypus*) was satellite-tagged on Muskeget Island 14 January 2015 using an unused tag purchased with AMAPPS funds for turtles. In addition, as an expansion of the AMAPPS I program using resources from NOAA Fisheries and partners other than BOEM and the US Navy, a multi-agency team conducted gray seal weaned pup live capture and biological sampling on Muskeget Island and South Monomoy Islands, MA from 11 – 17 January 2015. One hundred and twenty-eight pups (64 female; 59 male, 5 gender not noted) were captured. A suite of biological measurements and samples (e.g., weight, lengths, girth, blood, hair, skin, whisker, and mucous swabs) were collected. Small numbered and labeled green Allfex[1] Temple Ear Tags were attached to the hind flippers of most seals (tags were not attached to flippers that had open wounds).

OBJECTIVES

The goals of this project were to:

1) Collaborate with and expand Massachusetts Institute of Technology (MIT)'s influenza A virus (IAV) study in North Atlantic gray seal populations,
2) Collect biological samples for baseline health assessments, stable isotope, and heavy metal studies,
3) Expand external collaboration with other universities, government and non-government organizations and,
4) Evaluate South Monomoy Island as a gray seal pup sampling research site.

METHODS

<u>*SITE SELECTION, TIMING, LOGISTICS*</u>

Site selection and timing of the 11 – 17 January 2015 gray seal capture operations on Muskeget Island and South Monomoy Island (Figure C1) were based on prior MIT and NEFSC experience capturing weaned gray seals on the major pupping colony in U.S. waters, expected dates of peak pupping based on NEFSC aerial monitoring surveys, weather, and availability of boats and field personnel. Field personnel were divided into three independent sampling teams. One team stayed

[1] References to any specific commercial products, process, or service by trade name, trademark, or manufacturer are for descriptive purposes only and do not constitute or imply endorsement, recommendation, or favoring by the United States Government.

at the Snow Cabin on Muskeget Island, the second team made weather-dependent daily small boat excursions from Madaket Harbor, Nantucket, MA to Muskeget Island, and the third team stayed at the lighthouse cottage on the Monomoy National Wildlife Refuge.

CAPTURE, SAMPLING AND TAGGING

Gay seal capture operations followed protocols used in prior NEFSC projects which are similar to procedures followed in other regions Weaned pups were captured by walking up to an animal and physically restraining it (Figure C2), then transferring it to a specially-designed bag for weighing. Once weighed, seals were removed from the bag and physically restrained during sampling and flipper-tagging. One female pup was affixed with a satellite tag (Figure C3). The full sampling and tagging protocol for most seals included external examination, morphometrics, sex, molt stage, blood draw, whisker and hair clipping, mucous swabs (conjunctiva, nasal, rectal), and flipper tagging, which provided skin samples. Numbered and labeled flipper tags were attached to each hind flipper. The complete sampling protocols, however, were not conducted for each animal due to logistics, researchers requests (e.g., white coats only), animal activity level, or behavioral concerns (e.g., gray gums, open mouth breathing), presence of preexisting wounds, injuries, or infections. Digital images were taken of each seal. At completion of sampling, seals were left undisturbed.

RESULTS

Scientists from 12 different organizations participated in this project (Table C1).

Of the one hundred and twenty-eight seals that were captured, one was not flipper-tagged due to behavioral concerns and one was not flipper-tagged due to a preexisting abscess on the animal's hip (Table C2). Tissue samples (e.g., blood, skin, hair, whiskers, and mucous membranes) were collected for multiple research requests as well as for archiving, but the full suite of samples were not collected from each seal based on sample size requests and/or animal condition.

Of the 126 pups sampled for influenza A, 14 (11.1%) had detectable viral RNA. Of the positive samples, half were derived from nasal swabs (7/14), followed by conjunctival swabs (4/14) and rectal swabs (3/14). In addition, sera from 113 animals was screened for influenza antibodies; 22 (19.4%) were found to be seropositive.

The satellite-tagged seal was tracked for approximately one month before transmission ended. Upon leaving Muskeget she travelled in the waters south of Martha's Vineyard and Nantucket (Figure C4).

DISCUSSION

The 2015 project continued both the MIT longitudinal study on the ecology of influenza A virus in marine animal populations, and earlier collaborative studies initiated by NEFSC. The suite of biological samples will be analyzed to address research questions pertaining to disease, diet, contaminants, stock structure, population growth, and habitat requirements.

The 2015 effort will be continued in January 2016 in the Cape Cod and the Islands region. Further, participants on this project are also collaborating with seal researchers in Atlantic Canada, Greenland, and the United Kingdom to obtain a North Atlantic-wide understanding of gray seal population ecology. Findings from the New England component will be presented at scientific fora (e.g., 2015 Marine Mammal Biennial Conference), and in peer-reviewed journals.

The live capture and biological sampling conducted in this study demonstrated the value of collaborative research. The collective expertise of the participants helped to ensure that the project protocols were implemented in an efficient and safe manner. The collaboration also provided researchers the opportunity to share their expertise, provided in-the-field training, and was critical to meeting project goals and objectives.

DISPOSITION OF THE DATA

Electronic versions of the photos and the capture and samplings logs are archived at NEFSC.

PERMITS

NEFSC was authorized to conduct seal research activities during the study under Permit No. 17670-02 issued to the NEFSC by the NMFS Office of Protected Resources and U.S. Fish and Wildlife Service Special Use Permit #53514-130003.

ACKNOWLEDGEMENTS

The funds for the satellite tag were from Bureau of Ocean Energy Management (BOEM) and the US Navy through two Interagency Agreements for AMAPPS, as this tag was originally purchased for turtle research. The funding for the rest of this project came from the Massachusetts Institute of Technology, Centers for Excellence in Influenza Research and Surveillance, and NMFS Office of Science and Technology. We would like to thank the following: Mr. Crocker Snow for permission to access Muskeget Island and use of the Snow Cabin; the Monomoy National Wildlife Refuge for permission to use the facilities on Monomoy Island and at the Refuge Visitor's Center; NMFS National Marine Mammal Health and Stranding Response Program for providing biological sampling supplies; the Nantucket Harbormaster and Madaket Marine for docking space on Nantucket; the National Park Service; Cape Cod National Seashore for boat support; and Dr. Sarah Oktay from the University of Massachusetts Boston School for use of the Environment Nantucket Field Station.

Table C1. Participants in the January 2015 gray seal live capture, sampling, and tagging project.

Name	Affiliation
Andrea Bogomolni	WHOI/U. of Connecticut
Lynda Doughty	Marine Mammals of Maine
Kim Durham	Riverhead Foundation for Marine Research and Preservation
Beth Josephson	Integrated Statistics
Mandy Keogh	MIT affiliate
Milton Levin	U. of Connecticut
Richard Pace	NOAA/NMFS/NEFSC
Shannon Prendiville	Marine Mammals of Maine
Justin Richard	U. of Rhode Island
Asheley Simpson	Marine Mammals of Maine
Gordon T. Waring	NOAA/NMFS/NEFSC
Frederick Wenzel	NOAA/NMFS/NEFSC
Eric Matzen	Integrated Statistics
Holly Bayley	National Park Service
Belinda Rubinstein	National Marine Life Center
Wendy Puryear	MIT
Jonathon Runstadler	MIT
CT Harry	International Fund for Animal Welfare
Patty Schilling	New England Aquarium
Dominique Walk	Marine Mammals of Maine
Laura Thompson	Mystic Aquarium
Sophie Whoriskey	Mystic Aquarium
Lindsay Jasperse	U. of Connecticut
Christopher Bandoro	MIT
Kimberly Ryan Davis	MIT
Nichola Hill	MIT
Ray Molnar	Mystic Aquarium
Walter “Skip” Grad	Mystic Aquarium

Table C2. Summary of the January 2015 gray seal pup captures, Muskeget Island.

Tag ID#	Date	Site	Sex	Weight (kg)	Straight length (cm)	L Fore flipper length (cm)	L Rear flipper length (cm)	Ax. Girth
350	1/11/2015	Muskeget	M	42.6	105	20.5	30.5	103
351	1/12/2015	Muskeget	M	31.8	113	21	28	88
352	1/12/2015	Muskeget	F	29.8	114	23	27	92
353	1/12/2015	Muskeget	M	37.4	113	24	28	95
355	1/12/2015	Muskeget	F	33.8	105	23	29	95
354	1/12/2015	Muskeget	F	45.2	122	22	28	108
356	1/12/2015	Muskeget	M	34	102	18	27	92
357	1/12/2015	Muskeget	F	29.4	97	18	29	96
358	1/12/2015	Muskeget	F	25.2	101	23	22	80
359	1/12/2015	Muskeget	M	21.8	104	20	27	78
360	1/12/2015	Muskeget	F	48.4	103	17	28	106
361	1/12/2015	Muskeget	M	51.4	121	25	33.5	110
362	1/12/2015	Muskeget	M	51.2	127	24	32	105
363	1/12/2015	Muskeget	F	33.2	103	19	31	97
364	1/12/2015	Muskeget	F	38	103	22	31	96
365	1/12/2015	Muskeget	M	49.2	129	24	30	105
366	1/12/2015	Muskeget	F	39.6	110	19	32	98
367	1/12/2015	Muskeget	M	33.4	110	22	30	90
368	1/12/2015	Muskeget	M	47	107	25	28	106
369	1/12/2015	Muskeget	F	39.2	110	23	29	97
370	1/12/2015	Muskeget	M	52.6	110	22	29	112
371	1/12/2015	Muskeget	F	37.6	116	22	29	100
372	1/12/2015	Muskeget	M	45	114	30	31	99
373	1/13/2015	Muskeget	M	44.2	118	19	30	103
374	1/13/2015	Muskeget	M	41.6	112	24	31	104
375	1/13/2015	Muskeget	F	32	82	20	28	97
376	1/13/2015	Muskeget	M	48.4	111	20	31	107
377	1/13/2015	Muskeget	F	44	109	20	29	100
378	1/13/2015	Muskeget	F	36.8	102	23	29	95
379	1/13/2015	Muskeget	M	50.4	126	22	31	107
380	1/13/2015	Muskeget	F	37	103	21	30	95
381	1/13/2015	Muskeget	M	40	104	23	31	93
382	1/13/2015	Muskeget	M	43.6	113	NA	29	100
383	1/13/2015	Muskeget	M	41.6	111	19	30	96
384	1/13/2015	Muskeget	F	43.2	112	18	28	103
385	1/13/2015	Muskeget	F	49.4	120	20	29	110

386	1/13/2015	Muskeget	M	43.6	121	23	30	108
387	1/14/2015	Muskeget	F	35.4	112	22	29	103
388	1/14/2015	Muskeget	F	44.8	113	18	31	100
389	1/14/2015	Muskeget	M	46.4	128	22	29	103
390	1/14/2015	Muskeget	F	42.4	119	19	29	91
391	1/14/2015	Muskeget	F	37.6	114	22	32	99
392	1/14/2015	Muskeget	M	43.6	115	23	28	90
393	1/14/2015	Muskeget	F	43.6	105	23	30	100
394	1/14/2015	Muskeget	F	40.2	116	16	27	99
395	1/14/2015	Muskeget	M	46.2	113	18	27	105
396	1/14/2015	Muskeget	F	44.8	112	18	29	98
397	1/14/2015	Muskeget	F	39.6	104	18	25	98
398	1/14/2015	Muskeget	M	46.6	106	17	28	100
399	1/14/2015	Muskeget	M	28.8	92	14	19	84
400	1/14/2015	Muskeget	F	43.4	115	16	25	98
401	1/14/2015	Muskeget	F	33.4	100	15	24	89
402	1/14/2015	Muskeget	U	35.6	111	20	25	101
403	1/14/2015	Muskeget	F	50.6	97	19	26	NA
404	1/14/2015	Muskeget	M	37.2	109	18	25	98
405	1/15/2015	Muskeget	F	52.6	106	16	25	110
406	1/15/2015	Muskeget	F	45.8	120	15	23	112
407	1/15/2015	Muskeget	F	44.2	105	15	25	102
408	1/15/2015	Muskeget	M	55	119	17	29	98
409	1/15/2015	Muskeget	M	43.2	109	18	24	101
410	1/15/2015	Muskeget	M	38.6	101	20	25	47
411	1/15/2015	Muskeget	U	38.4	108	NA	27	NA
412	1/15/2015	Muskeget	F	33	95	14	22	107
413	1/15/2015	Muskeget	F	51.1	102	17	22	108
415	1/15/2015	Muskeget	U	45.2	113	20	25.5	100
416	1/15/2015	Muskeget	M	34.8	95	18	26	94
417	1/15/2015	Muskeget	F	60.8	119	16	26	NA
418	1/15/2015	Muskeget	M	42.6	98	15	28	97
N/A	1/15/2015	Muskeget	NA	48.2	NA	NA	NA	NA
300	1/12/2015	Monomoy	M	25.2	102	25	29	76
301	1/12/2015	Monomoy	F	30.2	95	18	23.5	91
302	1/12/2015	Monomoy	F	14.4	100.5	16.5	23	80
303	1/12/2015	Monomoy	M	47.8	102	19	28	110
304	1/12/2015	Monomoy	F	36.6	107	22	26	100
305	1/13/2015	Monomoy	M	48.4	118	21	29	106
306	1/13/2015	Monomoy	M	42.4	107.5	17.5	25	102.5
307	1/13/2015	Monomoy	F	37.4	105	16.5	22.5	98

308	1/13/2015	Monomoy	F	39.6	108	21	26	103
309	1/13/2015	Monomoy	M	31	97	17	25	89.5
310	1/14/2015	Monomoy	F	29	102	20	25	92
311	1/14/2015	Monomoy	M	36	114	19	28	105
312	1/14/2015	Monomoy	F	35.6	117	18	26	104
313	1/14/2015	Monomoy	M	29.4	114	19	27	91
314	1/14/2015	Monomoy	M	26.6	102	22.5	29	86
315	1/13/2015	Monomoy	M	48.2	126	21	29	107
316	1/13/2015	Monomoy	F	41	109	18	28	103
317	1/13/2015	Monomoy	F	38	106	21	27	99
318	1/13/2015	Monomoy	F	38.2	112	21.5	21	95.5
319	1/13/2015	Monomoy	F	29.8	114	17	27	87
320	1/12/2015	Monomoy	M	33	104	17	23	93
321	1/12/2015	Monomoy	M	26.4	113	21	23.5	82
322	1/12/2015	Monomoy	M	44.2	110	24	26	104
323	1/12/2015	Monomoy	M	22.8	104	24	28	79.5
324	1/12/2015	Monomoy	F	55.2	110	18	26	112
325	1/13/2015	Monomoy	F	32.4	111	20	27	94
326	1/13/2015	Monomoy	F	27.4	nd	19	27	102
327	1/13/2015	Monomoy	M	27.6	100	19	26.5	87
328	1/13/2015	Monomoy	M	30.2	104.5	19	28	100
329	1/13/2015	Monomoy	M	33.8	114	25	29	97
330	1/12/2015	Monomoy	M	40.4	108	22	25	84
331	1/12/2015	Monomoy	F	52.8	109	21	26	108
332	1/12/2015	Monomoy	M	18.2	99	20	26	76
333	1/12/2015	Monomoy	M	52.8	114	19	28	109
334	1/12/2015	Monomoy	M	51.8	124	19	29	93
335	1/13/2015	Monomoy	M	34.8	108	21	29	96
336	1/13/2015	Monomoy	M	37.4	112	18	18	nd
337	1/13/2015	Monomoy	M	38.6	112	21	29	95
338	1/13/2015	Monomoy	F	26.6	103	21.5	26	85
339	1/13/2015	Monomoy	M	44.4	104	18	22	112
340	1/14/2015	Monomoy	F	33.2	98	19	26	92
341	1/14/2015	Monomoy	M	45.8	121	20	28	99
342	1/14/2015	Monomoy	F	36.4	113	21	23	100
343	1/14/2015	Monomoy	F	43.6	122	21	31	102
344	1/14/2015	Monomoy	F	54	123	21	28 (R rear)	112
345	1/14/2015	Monomoy	F	21.8	110	18	25	82
346	1/14/2015	Monomoy	F	36.6	103	19	25	96
347	1/12/2015	Monomoy	F	20.2	103	19	26	77
348	1/12/2015	Monomoy	F	22.8	91	17	27	84

349	1/13/2015	Monomoy	F	30.2	102	18.5	25.5	93
not tagged	1/12/2015	Monomoy	NA	17.8	NA	NA	NA	NA
IFAW_38	1/14/2015	Monomoy	M	25.6	105	16	22.5	85
IFAW_91	1/14/2015	Monomoy	F	28.8	102	20	26	89
IFAW_99	1/14/2015	Monomoy	F	36	111	18	25	101
IFAW_37	1/14/2015	Monomoy	F	34	108	19	25	93
IFAW_96	1/15/2015	Monomoy	M	43	119	17	26	99
IFAW_95	1/15/2015	Monomoy	M	43.4	110	19	31	107
IFAW_39	1/15/2015	Monomoy	F	49.2	115	20	28	107

Figure C1. Muskeget and South Monomoy Islands. Image credit: Google Earth May 2015.

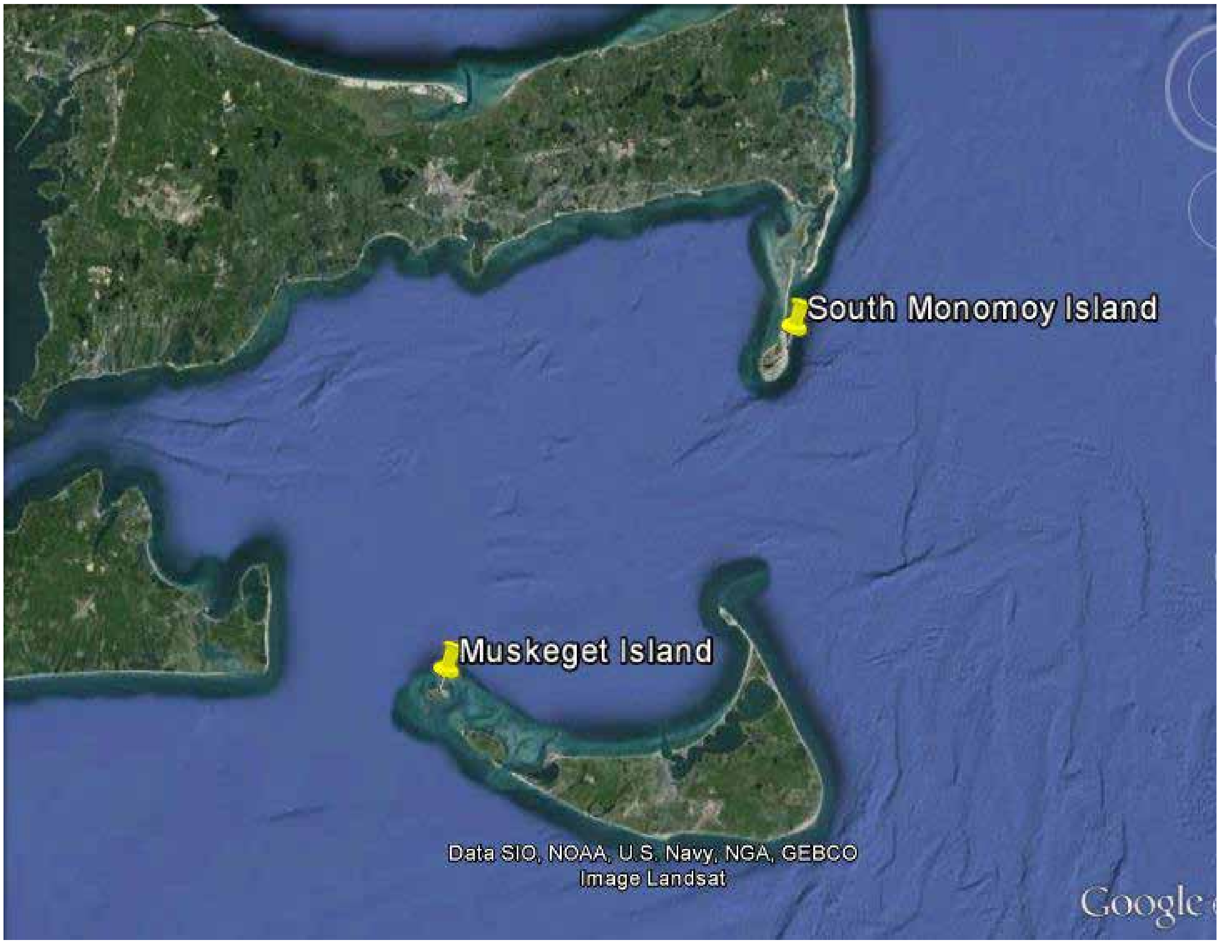
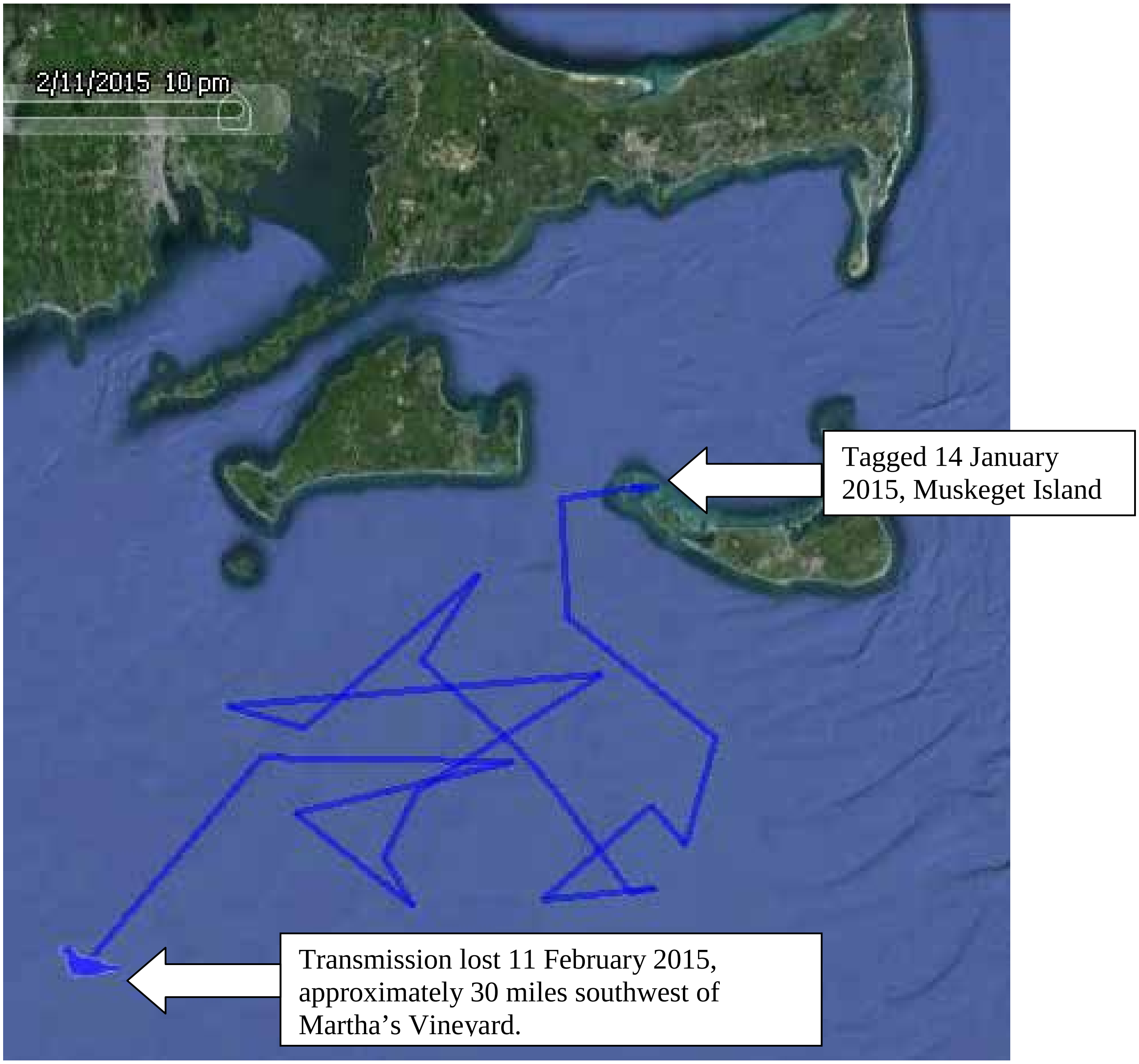


Figure C2. Restraining a weaned gray seal pup. Photo credit: Elizabeth Josephson, NEFSC.

Figure C3. Satellite-tagged weaned gray seal pup. Photo credit: Sophie Whoriskey, Mystic Aquarium

Figure C4. Track of satellite-tagged seal.



Appendix D: *Sei whale study, June 2015: Northeast Fisheries Science Center*

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SUMMARY

During 10 – 19 Jun 2015, a shipboard survey was conducted on the NOAA ship *Henry B. Bigelow* around Georges Bank. The goal was to collect distribution, ecosystem, and acoustic data on cetaceans, in particular sei whales (*Balaenoptera borealis*). To achieve this five teams collected data: two visual teams of data searched for marine mammals; a seabird team searched for birds; a team collected acoustic recordings using a towed array and sonobouys; and another team collected physical and biological data using the ship's sensor system, bongo nets, conductivity, temperature and depth(CTDs) probes, midwater trawls, and backscatter data via a Simrad EK60. In addition, a pilot study was conducted to test the efficacy of a video system, consisting of a high definition video camera and a long wave infrared camera, as compared to corresponding visual and acoustic observations. In total, over 2000 cetaceans and over 2500 birds were detected. Twelve sonobuoys were successfully deployed and over 28 hrs of acoustic data were recorded. CTD data were collected from 20 sites, 22 midwater trawls were conducted and backscatter data were collected during the times of the visual surveys and during some nights. Currently all of these data types are being analyzed.

OBJECTIVES

The overall goal of Leg 1 was to document the relationship between the distribution and abundance of cetaceans, sea turtles and seabirds within the study area relative to their physical and biological environment. This survey focused primarily on sei whales, with the following objectives:

1) Deploy the small boat to collect identification photographs and biopsy samples of as many individuals as possible.
2) Collect passive acoustic data via sonobuoys, dipping hydrophones and towed array.
3) Determine the distribution and relative abundance of plankton and prey species.
4) Develop a better understanding of habitat use and site fidelity for abundance and monitoring of critical areas.
5) Conduct a pilot study to test the efficacy of a video system consisting of a high definition video camera and a long wave infrared camera with corresponding visual and acoustic observations.

CRUISE PERIOD AND AREA

The total cruise period was originally scheduled for 23 days, from 7 June – 2 July 2015, with Leg 1 scheduled for 7 – 19 June 2015 on the NOAA ship *Henry B. Bigelow*. However, due to shortage of shipboard crew members and ongoing repairs needed to be able to deploy the small boat, the first leg of the cruise was delayed three days. Therefore the actual cruise period was 10 – 19 June 2015.

The study area for Leg 1 included the Great South Channel and the perimeter of the Georges Bank region, with limited effort crossing over to Browns Bank. The study region was between 40°N - 43°N latitude, and between 65°W - 70°W. This included waters within the US and Canadian economic exclusive zones (EEZ). See Figure D1.

METHODS

VISUAL MARINE MAMMAL-TURTLE SIGHTING TEAM

A line-transect style survey was conducted during daylight hours (approximately 0600 – 1900) using the two-independent-team procedure. Surveying was conducted in all weather conditions with the exception of rain or fog, while traveling at a survey speed of approximately 10 knots.

Scientific personnel formed two visual marine mammal-sea turtle sighting teams. The teams were stationed on the flying bridge (15.1 m above the sea surface) and anti-roll tank (11.8 m above the sea surface). Each team consisted of four trained observers. On each team, two observers utilized high-powered "big-eye" binoculars (Fujinon, 25x150) to scan from the bow of the ship to 90˚ port or starboard, while one observer scanned the trackline using hand-held binoculars and the naked eye, and recorded the sightings data from all team members. The fourth observer rested, and every 30 minutes the observers rotated positions within the team.

For either team, when an animal group (porpoise, dolphin, whale, seal, turtle or a few large fish species) was detected, the following data were recorded with VisSurv-NE:

1) Time sighting was initially detected, recorded to the nearest second,
2) Species composition of the group,
3) Radial distance between the team's platform and the location of the sighting, estimated either visually when not using the binoculars or by reticles when using binoculars,
4) Bearing between the line of sight to the group and the ship's track line; measured by a polarus mounted near the observer or a polarus at the base of the binoculars,
5) Best estimate of group size,
6) Direction of swim,
7) Number of calves,
8) Initial sighting cue,
9) Initial behavior of the group, and
10) Any comments on unusual markings or behavior.

At times when it was not possible to positively identify a species, survey effort was temporarily suspended ("off-effort") and the ship headed in a manner to intercept the animals in question. When the species identification and group size information were obtained, the ship proceeded back to the point on the track line where effort ended (or close to this point).

Because the focus of the survey was to search for sei whales, in areas of particularly high dolphin density, the visual observers did not record observations of all dolphin groups, as this sometimes became distracting from the primary survey goals. These periods of high dolphin density were noted, and when animal density decreased, all groups were again recorded as usual.

In addition to the sightings data, the following effort data were recorded every 30 minutes or when one of the factors changed:

1) Time of recording
2) Name and position of each observer

3) Weather conditions: swell direction relative to the ship's travel direction and height (in meters), apparent Beaufort sea state in front of the ship, presence of light or thick haze, rain or fog, amount of cloud coverage, visibility (i.e., approximate maximum distance that can be seen), and glare location and strength of glare within the glare swath (none, slight, moderate, severe).

At the same time, the location (latitude and longitude) of the ship when this information was entered was recorded by the ship's GPS via the SCS system which was connected to the data entry computers.

VISUAL SEABIRD SIGHTING TEAM

The seabird observer was also stationed on the flying bridge. For this survey, only a single observer conducted a visual daylight survey for marine birds, from approximately 0600 – 1900 hours with a one hour break at lunchtime and additional rest breaks as needed. Seabird observation effort employed a modified 300 meter strip and line-transect methodology. Data on seabird distribution and abundance were collected by identifying and enumerating all birds seen within a 300 meter arc on one side of the bow. The seabird observer maintained a visual unaided eye watch of the 300 meter survey strip, with frequent scans of the perimeter using hand-held binoculars for difficult-to-detect species. Binoculars (10x42 and 20x60 prism-stabilized) were used for distant scanning and to confirm species identification when needed. Ship-following species were counted once and subsequently carefully monitored to prevent re-counts. All birds, including non-marine species such as passerines, were recorded.

Operational limits are higher for seabird surveys then they are for marine mammal surveys. As a result, seabird survey effort was possible in sea states up to and including Beaufort 7. Seabird survey effort was suspended if the ship's speed over ground fell below five knots.

All data were entered in real time into a Panasonic Toughbook laptop running *Seebird (vers 4.3.6)*, a data collection program developed at the Southwest Fisheries Science Center. The software was linked to the ship's navigation system via a serial port. The following data were collected for each sighting: species identification, number of birds within a group, distance between the observer and the group, angle between the track line and the line of sight to the group, behavior, flight direction, flight height, age, sex and, if possible, molt condition. The sighting record received a corresponding time and GPS fix once the observer accepted the record and the software saved it to the laptop's internal hard drive. *Seebird* also added a time and location fix every 5 minutes. *Seebird* incorporates a time synchronization feature that ensures the computer clock matches the GPS clock, thereby facilitating post-processing of the seabird data with the ship's SCS data. All data underwent a quality assurance and data integrity check each evening and were saved to disk and to an external backup dataset.

INFRARED CAMERA TEAM

Seiche Ltd. and CSA Ocean sciences teamed together to test the current state of development and design of a video system to display and visually detect marine mammals. The goal of the pilot project was to test the efficacy of the video system with corresponding visual and acoustic observations. To further this effort NOAA NEFSC agreed to provide facilities to accommodate installation of the camera system and two technicians during HB15-03 Leg 1. The Seiche video system (RAIDS) utilizes a high definition video camera along with a long wave infrared camera.

Installation of the camera system and monitoring station took place June 5 – 9. The dual camera unit attached to a pan and tilt system that was mounted on a pedestal and secured to the forward rail near the center of the ship's flying bridge (Figure D2). The power and network distribution unit was attached to the forward mast on the flying bridge where it was easily connected to a nearby power and network access point. The monitoring station was set up in a dry lab across from the passive acoustic monitoring station. The monitoring station consisted of twin monitors, computer, network switch, and a RAID data storage system.

After the system was installed and power and network cables were connected, communication between the monitoring station and the camera system was established through the ship's network by registering the MAC addresses in the ship's network control software. All systems operated normally and numerous tests were performed prior to the ship's departure. Live feed from the camera system was monitoring during all daytime hours and opportunistically during nighttime hours by a rotating team of two observers. For the first three days, the marine mammal visual team reported sightings to the IR team observers so that the image contrast and resolution could be properly calibrated. After that point, the IR team worked independently to detect marine animal for the remainder of the survey.

PASSIVE ACOUSTIC TEAM

Passive acoustic effort on this survey included the deployment of SSQ-53F difar sonobuoys and a towed hydrophone array. This survey did not include a dedicated acoustic team. Instead, three trained acousticians with marine mammal observing experience alternated between visual sightings and passive acoustic monitoring efforts.

Sonobuoys were deployed each evening of the survey in the area where prey sampling was to take place, as well as opportunistically during daytime hours, with the goal of documenting baleen whale acoustic occurrence, particularly sei whale occurrence. Sonobuoys were typically programmed to transmit for 8 hours in difar mode. Sonobuoy signals were received at the ship via a WinRadio receiver and were routed through a Fireface 400 soundcard to a desktop or laptop computer recording the audio data. The software package Pamguard was used to map sonobuoy detections relative to the ship. Recording periods typically lasted from 1 – 8 hrs or as long as the ship was within range to receive the signal from the drifting sonobuoy.

The towed hydrophone array was deployed during daytime hours, only along the shelf break portion of the survey in waters 100 m or greater in depth. The array was comprised of two modular, oil-filled sections (the end-array and in-line array), which were separated by 30 m of cable. The end-array consisted of 3 "mid-frequency" elements (APC International, 42-1021), 2 "high-frequency" elements (Reson, TC 4013), and a depth sensor (Keller America, PA7FLE). The in-line array consisted of 3 "mid-frequency" elements (APC International, 42-1021). The array was towed 300 m behind the ship. Array depth typically varied between 8 – 12 m when deployed at the typical survey speed of 10 kts. Sound speed data at the tow depth of the array were extracted from morning CTD casts.

Acoustic data from the towed hydrophone array were routed to a custom-built Acoustic Recording System that encompassed all signal conditioning, including A/D conversion, filtering, and gain. Data were filtered at 1000 Hz, and variable gain between 20 – 40 dB was added depending on the relative levels of signal and noise. The recording system incorporated two National Instruments soundcards (NI USB-6356). One soundcard sampled the six mid-frequency channels at 192 kHz, the other sampled the two high-frequency channels at 300-500 kHz, both at a resolution of 16 bits. Digitized acoustic data were recorded directly onto laptop and desktop computer hard drives using the software program Pamguard (http://www.pamguard.org/home.shtml), which also recorded simultaneous GPS data, continuous depth data, and allowed manual entry of corresponding notes. Two channels of analog data were also routed to an external RME Fireface 400 soundcard and a separate desktop computer, specifically for the purpose of real-time detection and tracking of vocal animals using the software packages WhalTrak and Ishmael.

HYDROGRAPHIC/BONGO/PLANKTON SAMPLES

For more details on the physical and biological data collected from this and other surveys, please refer to Appendix H.

In brief, in addition to the ship's SCS logger system that continuously recorded oceanographic data from the ship's sensors, the following was conducted:

- Conductivity, Temperature, and Depth Profilers (CTD) with a dissolved oxygen sensor collected water column characteristics;
- Sea water samples were taken for the purpose of correcting conductivity;
- Bongo plankton nets equipped with a CTD collected plankton samples:
- Multi-frequency (18, 38, 70, 120, and 200 kHz) Simrad EK60 data were collected continuously throughout the cruise, in either active or passive mode;
- Midwater trawl hauls collected pelagic fish and macrozooplankton and were set to sample acoustic backscatter locations.

RESULTS

Scientific personnel involved in the Leg 1 of this cruise are listed in Table D1.

VISUAL MARINE MAMMAL-TURTLE SIGHTING TEAM

The visual marine mammal and turtle team surveyed about 1228 km while on-effort during 8 sea-days. The first sea day (10 June) was spent in transit to the study area. The vessel initiated their return transit on 18 June, therefore the last "sea day" (19 June) was spent at the dock in Newport, RI.

During the on-effort track lines, the visual teams sighted 19 cetacean species or species groups, 2 turtle species or species groups, and 4 fish species or species groups (Tables D2 and D3). For cetaceans, the upper team detected 346 groups for a total of 2040 individuals. Similarly, the lower team detected 358 groups for a total of 1824 individuals. Note that some of these groups were detected by both teams. Few turtles were sighted, only 1 individual by members of the upper team.

In addition, many ocean sunfish were sighted; 44 groups were sighted by the upper team and 34 by the lower team.

One biopsy sample was collected from a dead and drifting pilot whale.

Distribution maps of sighting locations of the cetaceans, turtles, and fishes are displayed in Figures D3 – D8. Note these are locations of sightings seen by only the upper team.

VISUAL SEABIRD SIGHTING TEAM

The flying bridge of the NOAA ship *Henry B. Bigelow* provided a stable platform and afforded good visibility for the seabird team. Seabird survey effort was conducted on eight days. Nomenclature follows that used in *The Clements Checklist of Birds of the World*. 6th edition, Cornell University Press 2007, with electronic updates to 2014.

A summary of all 2516 birds representing 21 species seen while on effort is presented in Table D4 (Figures D9 – D12). Note that data presented in this table only include detections made within the 300 m survey strip. An additional three species were seen beyond the 300 m survey strip and are included in the summary for the sake of completeness. The four commonest species, listed in order of decreasing abundance were: Great Shearwater (*Puffinus gravis*), Sooty Shearwater (*Puffinus griseus*), Wilson's Storm-Petrel (*Oceanites oceanicus*) and Cory's Shearwater (*Calonectris diomedea*), accounted for almost 79% of all the birds seen. This is typical of early summer seabird distribution and abundance in this area of the northwest Atlantic Ocean. These four species are austral breeders that spend summer in the northwest Atlantic Ocean during their non-breeding season. Throughout the cross-shelf survey lines (e.g., Lines 3, 4, 5, 13, 17 and 18) seabird distribution was patchy yet often predictable. High densities were found along the northern shelf break of Georges Bank, particularly in the vicinity of the Northeast Peak. These concentrations were composed primarily of Cory's and Great Shearwaters. These latter two species, especially the former, were also frequently seen feeding in association with groups of Atlantic white-sided dolphin (*Lagenorhynchus acutus*). Wilson's Storm-Petrel was typically found in areas of upwelling seaward of the shelf break, often in association with Leach's Storm-Petrel (*Oceanodroma leucorhoa*) who is a Northern Hemisphere breeder.

The seabird survey effort collected valuable spatial and temporal information in areas that historically have received little systematic observer effort. The sighting of yet another Barolo Shearwater (*Puffinus baroli*) adds to the handful of records from this area. It is generally considered to be very rare anywhere in the northwest Atlantic Ocean. The normal breeding range includes islands off northwest Africa (Canary Islands, Azores, Desertas and Salvage), but its at-sea distribution is less clear. Its status in North American waters, inferred from only a few sightings in the last 100 years, is poorly known. However, at least one has been seen on all previous spring/summer AMAPPS surveys since 2011 and so is perhaps a regular but rare late spring to early fall visitor off New England and Nova Scotia. Additional surveys will no doubt provide further information on this enigmatic species.

Six Audubon's Shearwaters (*Puffinus lherminieri*) were noteworthy for time and location, being unusual this far north so early in the season. In addition to those seen along the shelf break in the vicinity of Powell, Lydonia, and Oceanographer Canyons, two were in Canadian waters where this species is extremely rare. However, this perceived rarity may simply be a result of survey bias. Although Audubon's Shearwater is common during summer in warmer water farther south, its status this far north, particularly in Canadian waters, is less clear; presumably its occurrence is closely related to the presence of warmer sea surface temperatures. Additional surveys will help clarify this species' true status in the northwest Atlantic Ocean.

INFRARED CAMERA TEAM

Observations with the camera system began the morning of 11 June 2015 and despite some fog all systems functioned nominally. Over the course of the first couple days we made several adjustments to the monitoring system which improved marine mammal detectability. Manual and automatic scanning techniques using the pan and tilt system were refined and occasionally troubleshot. Over the course of the first three days camera observations were coordinated with visual observers to maximize sightings with the camera system and obtain recordings of several species of marine mammals. These recordings will aid to further develop the automatic detection routines for the camera system. The final several days camera observations were conducted independently of visual observers and logs from both will be compared to determine the efficacy of the system.

Overall this test of the twin camera system provided an excellent platform to shake down the system and compare its capabilities to those of visual observers. A few areas that were identified as needing continued development were the network bandwidth compatibilities, user front end controls, and image window adjustment. The sighting ratio compared to an equivalent visual observer will require further analysis to determine; however, post survey conversations suggest the camera system obtained a similar sighting rate as the visual observers.

PASSIVE ACOUSTIC DETECTION TEAM

Over the course of the survey, 15 sonobuoys were deployed, of which 12 were successful (Table D5). In addition, acoustic monitoring effort using the towed hydrophone array was conducted on four sea-days, for nearly 29 hrs. Post-processing of passive acoustic data will be conducted to extract all acoustic events, localize individual groups and compare visual and acoustic detection rates, and evaluate performance of species-specific classifiers.

HYDROGRAPHIC/BONGO/PLANKTON SAMPLES

For more details on the physical and biological data collected from this and other surveys, please refer to Appendix H.

In brief, the following was collected during this cruise:

- Physical oceanographic and atmospheric data collected by the ship's SCS system are listed in Table D6.
- CTD and bongo samples were collected from 22 casts at a total of 20 sites; the SBE 9/11+ CTD was deployed at one site.
- Midwater trawls were deployed 21 times and the haul catches varied depending on the area fished.
- Multifrequency echosounder data were collected continuously in either active or passive mode.

DISPOSITION OF THE DATA

All visual and passive acoustic data collected will be maintained by the Protected Species Branch at the Northeast Fisheries Science Center (NEFSC) in Woods Hole, MA. Visual sightings data are archived in the NEFSC's Oracle database and will be submitted to OBIS-SEAMAP. Seabird data have been submitted to the Seabird Compendium.

All hydrographic data collected are maintained by the Fishery Oceanography Branch at the NEFSC in Woods Hole, MA. Hydrographic data can be accessed through the Oceanography web site http://www.nefsc.noaa.gov/epd/ocean/MainPage/ioos.html or the NEFSC's Oracle database.

Trawl samples were discarded at sea after positively identified and recorded.

All plankton samples collected are maintained by the Fishery Oceanography Branch at the NEFSC in Narragansett RI. Plankton samples were sent to Poland for identification. Plankton data can be accessed through the NEFSC's Oracle database after about March 2016.

All active acoustic data are archived and maintained by the NEFSC Data Management Services (DMS) branch at the NEFSC. In addition, all EK60 data are archived and maintained at NOAA's NGDC in Boulder, CO.

PERMITS

NEFSC was authorized to conduct the marine mammal related research activities during this survey under US Permit No. 17355 issued to the NEFSC by the NMFS Office of Protected Resources and SARA Permit No. 330996 issued to the NEFSC by Fisheries and Oceans Canada.

ACKNOWLEDGEMENTS

The funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements for the AMAPPS project. Staff time was provided for by the NOAA Fisheries Service, Northeast Fisheries Science Center (NEFSC), Protected Species Branch, Oceanography Branch, and Behavioral Ecology Branch. We would like to thank the crew and scientists of the NOAA ship *Henry B. Bigelow* cruise.

Table D1. Scientific personnel involved in the HB15-03 survey. FN = Foreign National.

Personnel	Title	Organization
Danielle Cholewiak	Chief Scientist	Integrated Statistics, Woods Hole, MA
Genevieve Davis	Mammal Observer/ Acoustics	Integrated Statistics, Woods Hole, MA
Peter Duley	Mammal Observer	NOAA NEFSC, Woods Hole, MA
Michael Force (FN)	Seabird Observer	Integrated Statistics, Woods Hole, MA
Julianne Gurnee	Mammal Observer/ Acoustics	Integrated Statistics, Woods Hole, MA
Michael Jech	Oceanographer /Trawl Survey	NOAA NEFSC, Woods Hole, MA
Marjorie Lyssikatos	Mammal Observer	NOAA NEFSC, Woods Hole, MA
Jeff Martin	Infra-red camera Observer	CSA Ocean Sciences
Hilary Moors-Murphy (FN)	Mammal Observer	Department of Fisheries & Oceans, Canada
Christopher Orphanides	Mammal Observer	NOAA NEFSC, Woods Hole, MA
Thomas Savage	Teacher-At-Sea	NOAA Teacher at Sea Program
Lorenzo Scala (FN)	Infra-red Camera Observer	Seiche, Ltd.
Christopher Tremblay	Mammal Observer/ Acoustics	Integrated Statistics, Woods Hole, MA
Melissa Warden	Mammal Observer	Integrated Statistics, Woods Hole, MA
Suzanne Yin	Mammal Observer	Integrated Statistics, Woods Hole, MA

Table D2. Number of groups and individuals of cetacean species detected by the upper and lower marine mammal/turtle visual observer teams during on-effort tracklines. Note that some, but not all, groups detected by one team were also detected by the other team.

Species Name		Number of groups		Number of individuals	
		lower	upper	lower	upper
Bottlenose dolphin, common	*Tursiops truncatus*	7	5	57	74
Common dolphin, short-beaked	*Delphinus delphis*	14	25	132	408
Cuvier's beaked whale	*Ziphius cavirostris*	2	1	3	1
Fin whale	*Balaenoptera physalus*	15	15	25	25
Fin/sei whales	*B. physalus or B. borealis*	1	6	1	10
Humpback whale	*Megaptera novaeangliae*	39	30	68	48
Lagenorhynchus sp.	*Lagenorhynchus sp.*	2	7	36	96
Minke whale	*B. acutorostrata*	25	14	25	16
Pilot whales spp.	*Globicephala spp.*	33	26	123	121
Right whale	*Eubalaena glacialis*	1	1	1	1
Risso's dolphin	*Grampus griseus*	10	9	66	48
Rough-toothed dolphin	*Steno bredanensis*	0	1	0	2
Sei whale	*Balaenoptera borealis*	1	4	2	5
Sowerby's beaked whale	*Mesoplodon bidens*	2	4	7	11
Sperm whale	*Physeter macrocephalus*	12	10	19	15
Striped dolphin	*Stenella coeruleoalba*	1	1	20	15
Unid. dolphin	*Delphinidae*	62	68	352	460
Unid. whale	*Mysticeti/Odontoceti*	59	76	76	112
Unid. ziphiid	*Ziphiidae*	3	1	5	3
White-sided dolphin	*Lagenorhynchus acutus*	69	42	806	569
TOTAL CETACEANS		**358**	**346**	**1824**	**2040**

Table D3. Number of groups and individuals of large fish and turtles detected by the marine mammal/turtle visual teams during on-effort track lines. Note, some, but not all, groups detected by one team were also detected by the other team.

Species		Number of groups		Number of individuals	
		lower	upper	lower	upper
Basking shark	*Cetorhinus maximus*	10	8	11	8
Manta rays spp.	*Manta spp.*	0	2	0	2
Ocean sunfish	*Mola mola*	34	44	35	50
Shark spp.		1	1	1	1
Leatherback turtle	*Dermochelys coriacea*	0	1	0	1
Unid hardshell turtle	*Chelonioidea*	0	1	0	1
TOTAL ALL SPECIES		**45**	**57**	**47**	**63**

Table D4. Number of groups and individual birds detected within the 300 m strip during the NOAA ship *Henry B. Bigelow* survey.

Species		**Total Individuals***	**Relative Abundance (%)**	**IUCN status (2015.2)**
Red-throated Loon	*Gavia stellata*	1	0.04	Least Concern
Northern Fulmar	*Fulmarus glacialis*	188	7.47	Least Concern
Cory's Shearwater	*Calonectris diomedea*	260	10.33	Least Concern
Great Shearwater	*Puffinus gravis*	614	24.39	Least Concern
Sooty Shearwater	*Puffinus griseus*	601	23.88	Near Threatened
Manx Shearwater	*Puffinus puffinus*	15	0.6	Least Concern
Audubon's Shearwater	*Puffinus lherminieri*	6	0.24	Least Concern
Wilson's Storm-Petrel	*Oceanites oceanicus*	512	20.34	Least Concern
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	212	8.42	Least Concern
Northern Gannet	*Morus bassanus*	4	0.16	Least Concern
Red Phalarope	*Phalaropus fulicarius*	2	0.08	Least Concern
South Polar Skua	*Stercorarius maccormicki*	8	0.32	Least Concern
Pomarine Jaeger	*Stercorarius pomarinus*	5	0.2	Least Concern
Parasitic Jaeger	*Stercorarius parasiticus*	2	0.08	not assessed
Long-tailed Jaeger	*Stercorarius longicaudus*	4	0.16	Least Concern
Dovekie	*Alle alle*	1	0.04	Least Concern
Common Murre	*Uria aalge*	1	0.04	Least Concern
Thick-billed Murre	*Uria lomvia*	1	0.04	Least Concern
Atlantic Puffin	*Fratercula arctica*	1	0.04	Least Concern
Herring Gull	*Larus argentatus*	40	1.59	Least Concern
Great Black-backed Gull	*Larus marinus*	38	1.51	Least Concern
		2516		
* Off transect species not included in the totals				
Addititional species seen off transect:				
Barolo Shearwater	*Puffinus baroli*	1	N/A	not assessed
Lesser Black-backed Gull	*Larus fuscus*	6	N/A	Least Concern
Barn Swallow	*Hirundo rustica*	1	N/A	Least Concern

Table D5. Summary of passive acoustic recording effort

SONOBUOYS	Number of sonobuoys deployed	15
	Successful sonobuoy deployments	*12*
	Failed sonobuoy deployments	*3*
TOWED ARRAY	Days with acoustic effort	4
	Daytime recording time (hh:mm)	28:27

Table D6. SCS data collected once /second during the survey and stored in a user created file.

Date (MM/DD/YYYY)	
Time (hh:mm:ss)	TSG-Conductivity (s/m)
EK60-38kHz-Depth (m)	TSG-External-Temp (ºC)
EK60-18kHz-Depth (m)	TSG-InternalTemp (ºC)
ADCP-Depth (m)	TSG-Salinity (PSU)
ME70-Depth (m)	TSG-Sound-Velocity (m/s)
ES60-50kHz-Depth (m)	MX420-Time (GMT)
Doppler-Depth (m)	MX420-COG (º)
Air-Temp (ºC)	MX420-SOG (Kts)
Barometer-2 (mbar)	MX420-Lat (DDMM.MM)
YOUNG-TWIND-Direction (º)	MX420-Lon (DDMM.MM)
YOUNG-TWIND-Speed (Kts)	Doppler-F/A-BottomSpeed (Kts)
Rel-Humidity (%)	Doppler-F/A-WaterSpeed (Kts)
Rad-Case-Temp (ºC)	Doppler-P/S-BottomSpeed (Kts)
Rad-Dome-Temp (ºC)	Doppler-P/S-WaterSpeed (Kts)
Rad-Long-Wave-Flux (W/m^2)	High-Sea Temp (ºC)
Rad-Short-Wave-Flux (W/m^2)	POSMV – Time (hhmmss)
ADCP-F/A – GroundSpeed (Kts)	POSMV – Elevation (m)
ADCP-F/A – WaterSpeed (Kts)	POSMV – Heading (º)
ADCP-P/S – GroundSpeed (Kts)	POSMV – COG (Kts)
ADCP-P/S – WaterSpeed (Kts)	POSMV – SOG (Kts)
Gyro (º)	POSMV – Latitude (DDMM.MM)
POSMV – Quality (1=std)	POSMV – Longitude (DDMM.MM)
POSMV – Sats (none)	POSMV – hdops (none)

Figure D1. Survey tracklines covered by the marine mammal /sea turtle visual team during HB15-03 Leg 1. The US exclusive economic zone (EEZ) and the 100 m, 200 m, 1000 m and 2000m depth contours are also displayed.

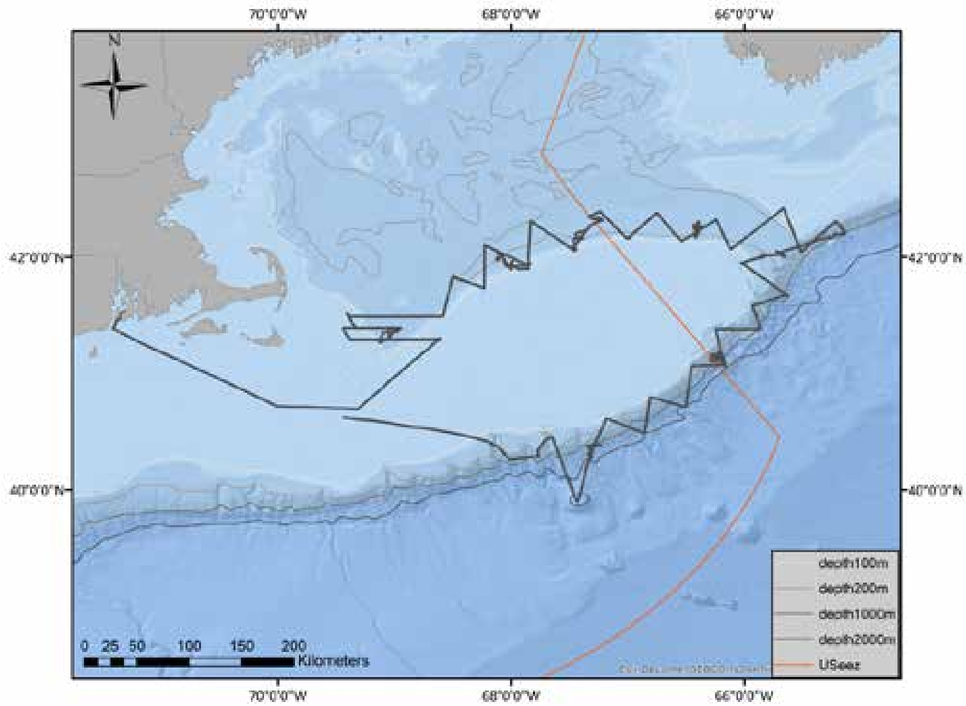


Figure D2. Photograph of infrared camera setup on the flying bridge for HB15-03 Leg 1.

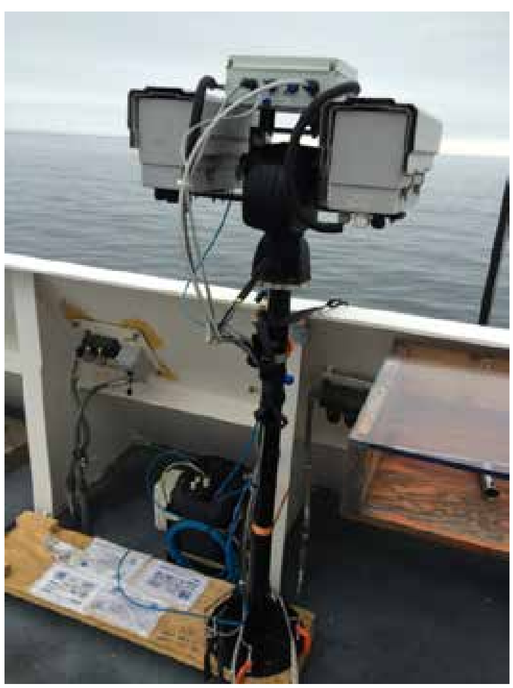


Figure D3. Location of fin and sei whale sightings during HB15-03 Leg 1.

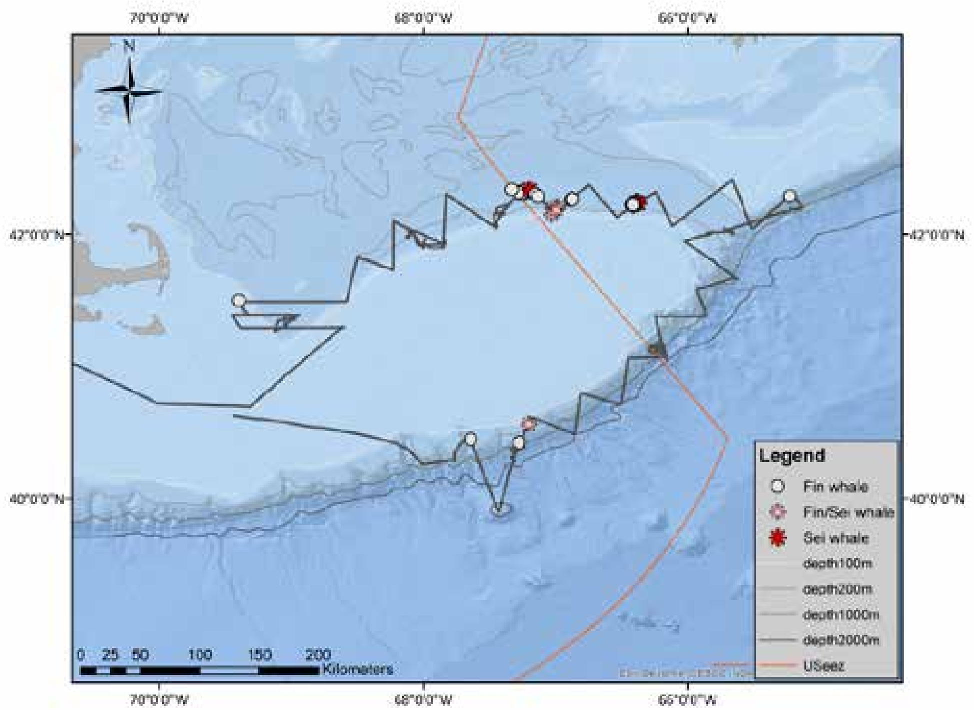


Figure D4. Location of humpback, minke and north atlantic right whale sightings during HB15-03 Leg 1.

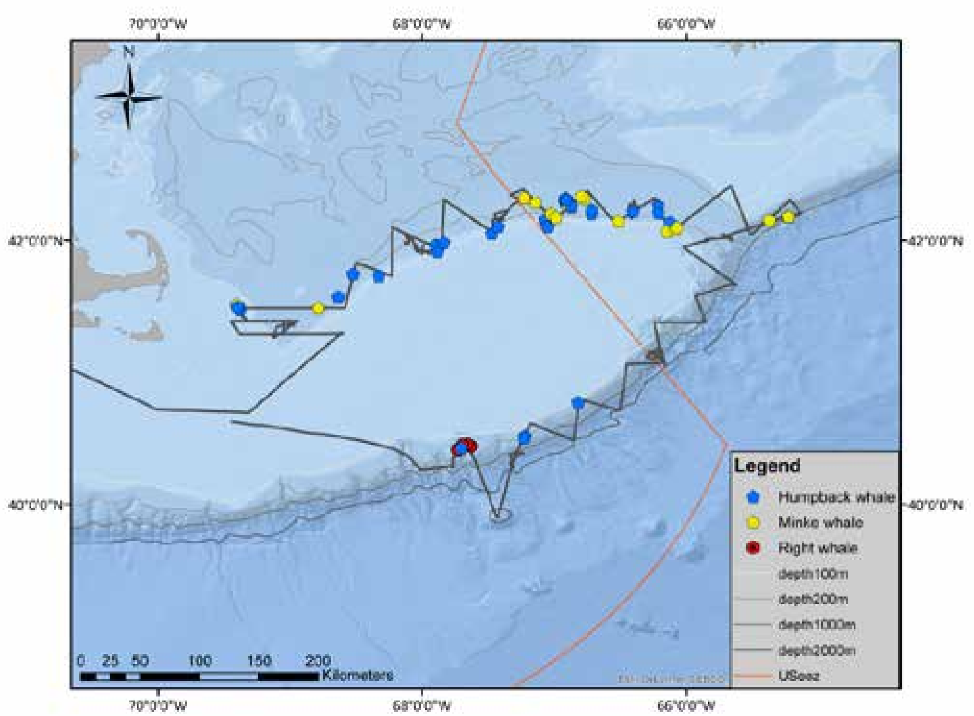


Figure D5. Location of delphinid sightings during HB15-03 Leg 1.

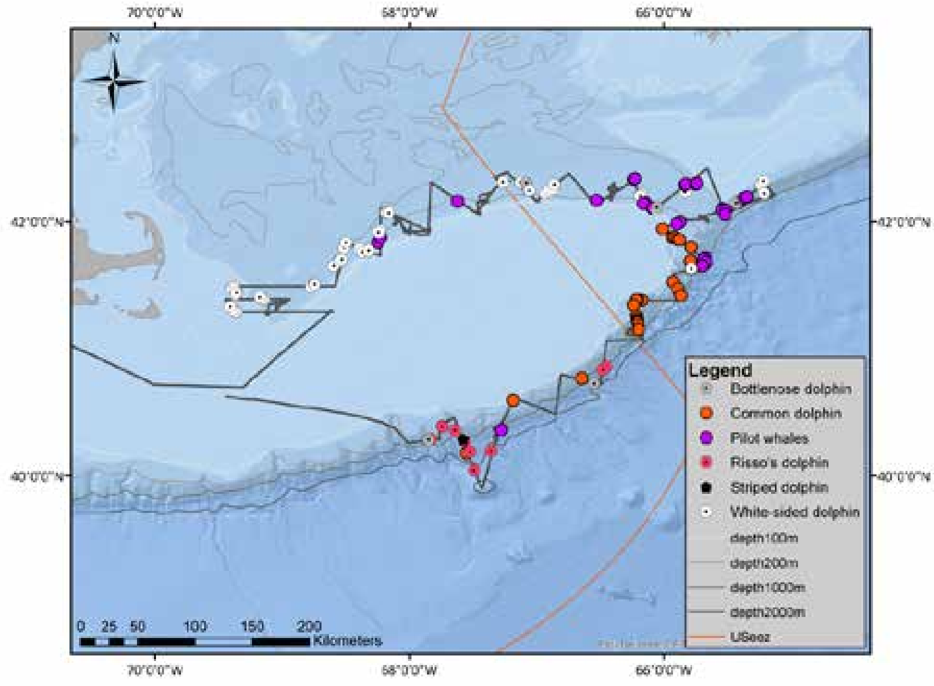


Figure D6. Location of beaked and sperm whale sightings during HB15-03 Leg 1.

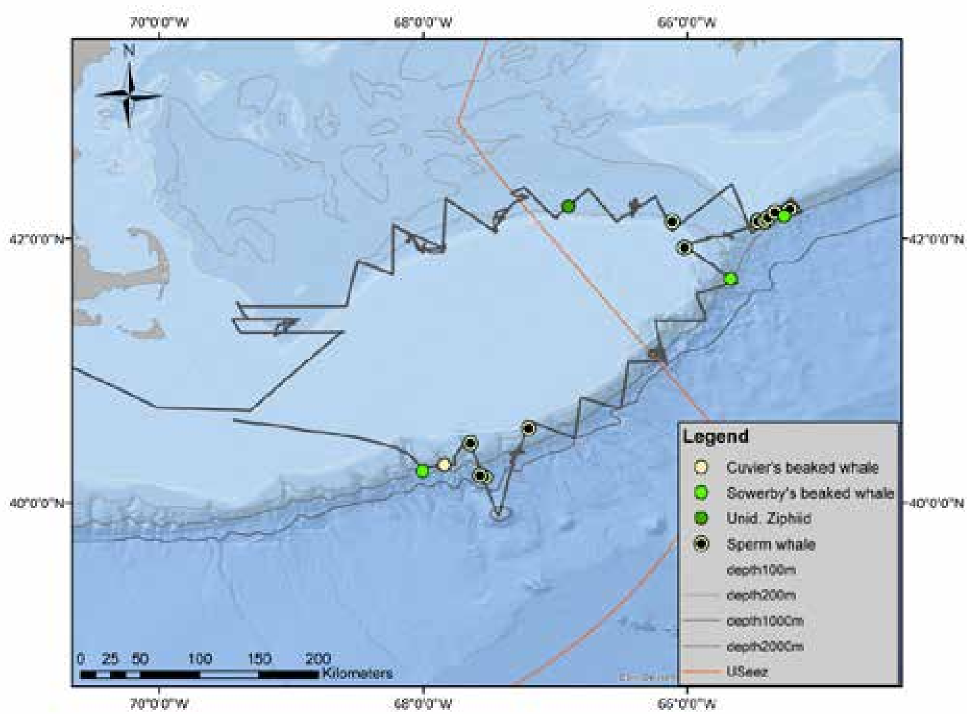


Figure D7. Location of unidentified dolphins, as well as large and small whales, sighted during HB15-03 Leg 1.

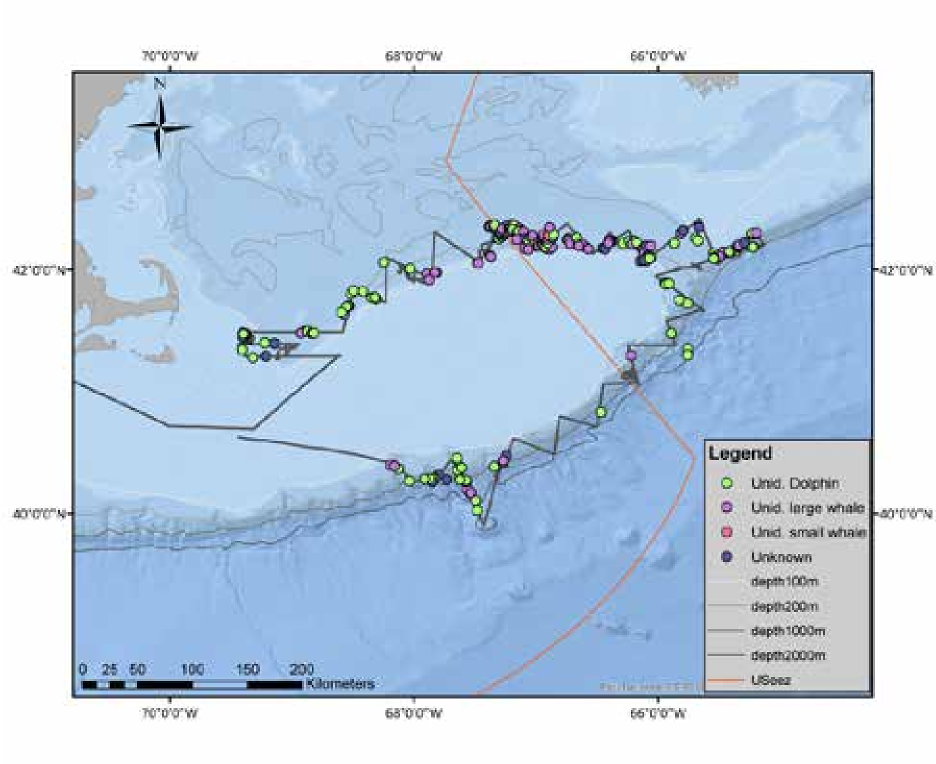


Figure D8. Location of sharks, rays and turtles sighted during HB15-03 Leg 1.

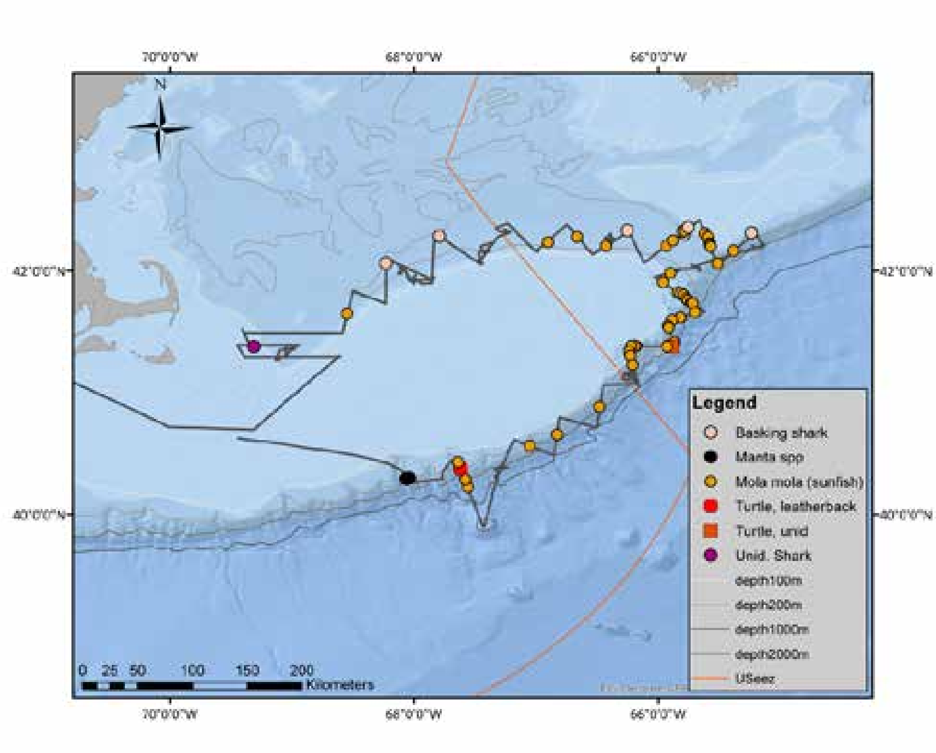


Figure D9. Location of shearwaters sighted during HB15-03 Leg 1. The trackline effort in this and subsequent seabird maps shows only the periods when the seabird observer was "on effort". Shearwater sightings include 6 Audubon's and 15 Manx shearwaters.

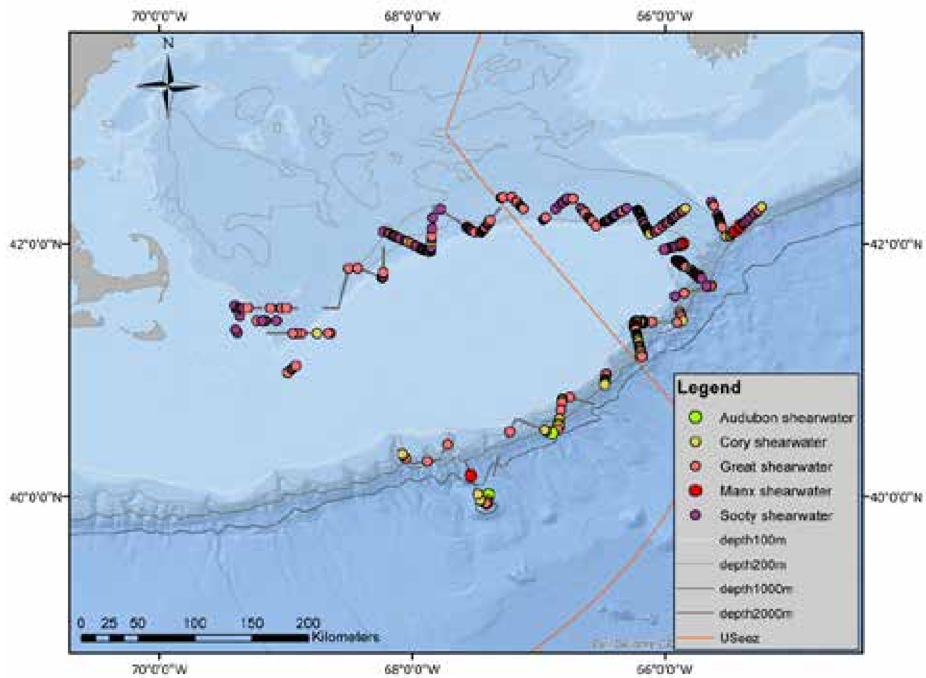


Figure D10. Map of storm petrel sightings during HB15-03 Leg 1. Two species were sighted, least storm petrel (LESP) and Wilson's storm petrel (WISP).

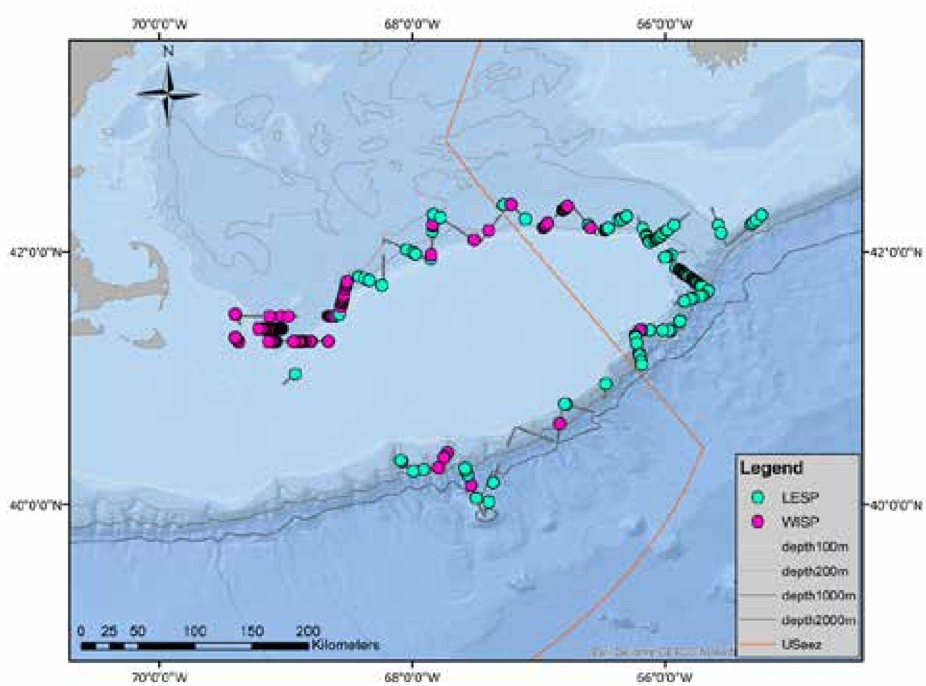


Figure D11. Map of gulls and jaegers sighted during HB15-03 Leg 1. Six species are shown: Great black-backed gull (GBBG), herring gull (HERG), lesser black-backed gull (LBBG), long-tailed jaeger (LTJA), parasitic jaeger (PAJA), pomerine jaeger (POJA), and south polar skuas (SPSK).

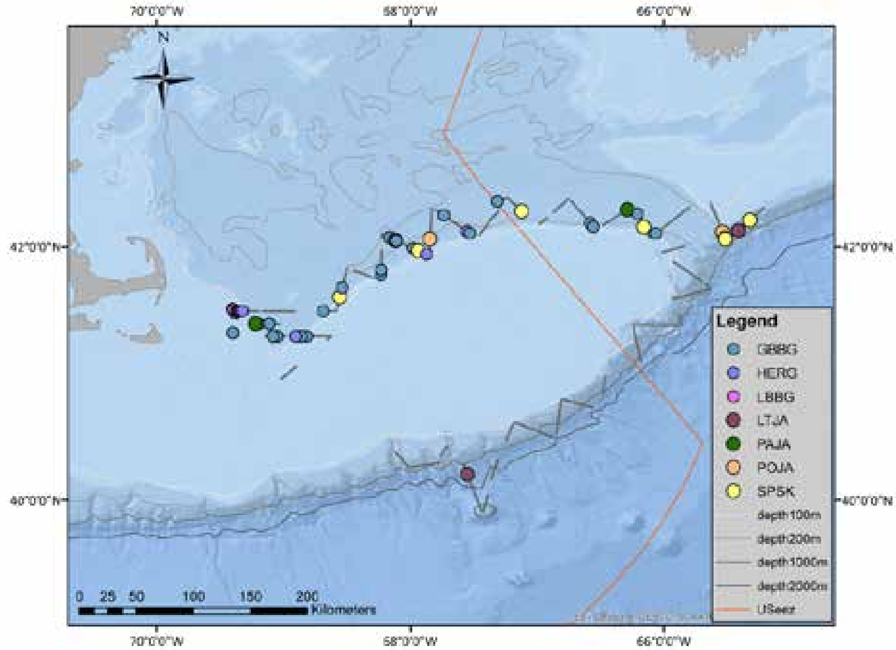
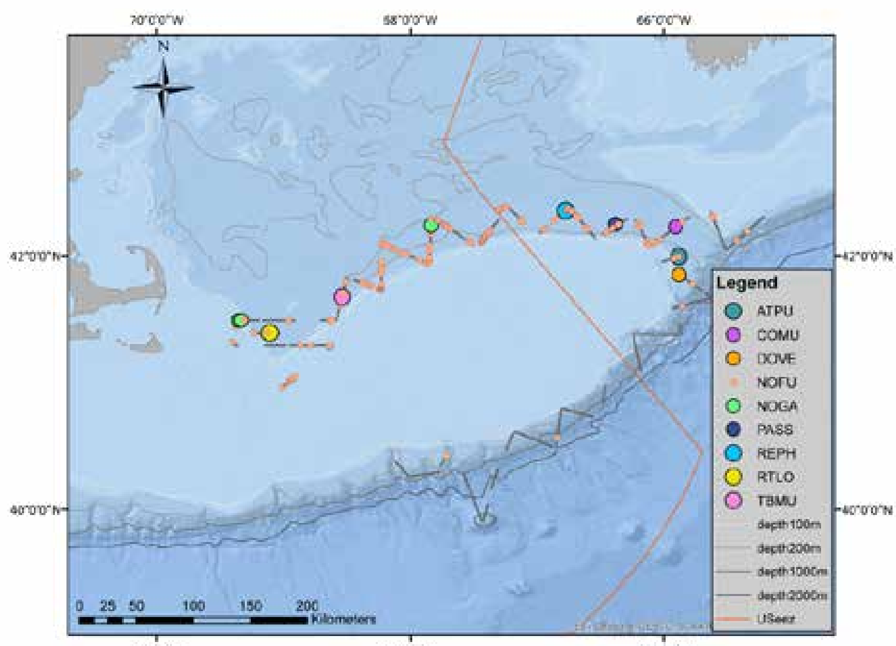


Figure D12. Map of alcids and other avian species sighted during HB15-03 Leg 1, including Atlantic puffin (ATPU), common murre (COMU), dovekie (DOVE), northern fulmar (NOFU), northern gannet (NOGA), unidentified passerine (PASS), red pharalope (REPH), red-throated loon (RTLO), and thick-billed murre (TBMU).



Appendix E: *Turtle tagging study, June/July 2015: Northeast Fisheries Science Center*

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SUMMARY

To estimate the amount of time sea turtles are available to line-transect abundance surveys, the NOAA ship *Henry B. Bigelow* was used to capture and tag 3 loggerhead sea turtles (*Caretta caretta*) and 1 Kemp's ridley turtle (*Lepidochelys kempii*) that were located on the southern flank of Georges Bank during 23 Jun – 2 Jul 2015. These captures also allowed an opportunity to collect associated biological information from these tagged animals. A Puma fixed wing unmanned aerial system was deployed for the first time from a large ship and was used to expand the ability to detect turtles over the standard searching with high powered binoculars and naked eye. A high-frequency acoustic recording package (HARP) was deployed near Corsair Canyon and will be recording passive acoustic data for one year. In addition to searching for turtles to tag, marine mammals and large fish species sightings were recorded, passive acoustic recordings were made, and samples of potential turtle prey were taken using a visual plankton recorder, a Sound Metrics Didson 300 imaging sonar, and a paired Go-Pros video system.

OBJECTIVES

As part of the current AMAPPS project as well as historic NOAA projects, millions of dollars have been spent on line-transect aerial surveys for protected species, yet the availability of protected species to aerial surveys is not well known, particularly for sea turtles northeast of Long Island. Data from satellite relayed data loggers can inform estimates of sea turtle availability. To address this need, our motivating objective was to locate, capture, sample, and satellite tag loggerhead sea turtles in the poorly understood area from the southern flank of Georges Bank through the Scotian Shelf.

The overall goal of Leg 2 of the NOAA ship *Henry B. Bigelow* summer cruise was to focus on sea turtle species, but to also collect priority information on marine mammal acoustics and oceanography. The specific objectives were:

1) Use big eyes, binoculars and Puma fixed wing unmanned aerial systems to locate sea turtles
2) Capture, bring on board, sample, and satellite tag hard-shelled sea turtles (primarily loggerheads)
3) Deploy a high-frequency acoustic recording package (HARP) along the shelf break near Corsair Canyon, to record passive acoustic data for one year
4) Collect passive acoustic data via towed hydrophone array, particularly for detection of beaked and sperm whales
5) Opportunistically record data on marine mammal visual sightings
6) Use conductivity, temperature and depth (CTDs) recorders to collect information on water column structure, particularly with reference to the large warm core rings along the shelf break

7) Be prepared to deploy instruments to assess gelatinous zooplankton, if large aggregations exist.

CRUISE PERIOD AND AREA

The total cruise period was originally scheduled for 23 days, from 7 June – 2 July 2015; however, several cruise days were lost due to due to shortage of shipboard crew members, ongoing repairs, and lack of necessary supplies. The final cruise period for the second leg was 23 June – 2 July 2015.

The study area for Leg 2 included the shelf break area from south of Newport, and along the southern flank of Georges Bank into Canadian waters (Figure E1). The study region was between 40°N - 43°N latitude, and between 65°W - 71°W. This included waters within the US and Canadian economic exclusive zones (EEZ).

METHODS

UNMANNED AIRCRAFT SYSTEMS (UAS) TEAM

To increase our ability to sight and mark the location of sea turtles, we partnered with the NOAA UAS program to create a team that operated three fixed-wing Puma unmanned aircraft systems. The NOAA RQ-20 Puma were operated in accordance with the AeroVironment Puma Operator's Manual, NOAA Aircraft Operations Center (AOC) Airworthiness Certificate, Federal Aviation Administration (FAA) Certificate of Authorization(s) and a documented Standard Operating Procedures (SOP). This UAS mission was the first NOAA UAS mission aboard a NOAA ship in the Atlantic Ocean. It was also the first NMFS-permitted activity using UASs for turtle research. The mission was also unique in that we operated the UASs beyond the line of sight.

VISUAL TURTLE SIGHTING TEAM

Transects were conducted during daylight hours. The direction of the transect was adjusted to optimize sighting conditions. Surveying was conducted in most weather conditions, except not in heavy rain or in seas that were too rough for safe small boat operations. Survey speed was adjusted according to sighting conditions. We sometimes surveys at 10 kts, but more typically at about 5 kts.

Most visual observers were located on the flying bridge (15.1 m above the sea surface). In the beginning of the cruise, we also had visual observers located on the anti-roll tank (11.8 m above the sea surface), but that platform was not optimal because it was difficult for those observers to follow a sighting as the ship maneuvered in preparation for small boat deployment.

The visual sighting team was part of a dynamic larger sightings, capture, and turtle handling team. When staff was not working on other science missions, all eight members of this team as well as scientific staff with other responsibilities (CS, Puma UAS team, oceanography, acoustics, and blood processing) were all supporting visual sightings operations. The size of this team shrank when scientists were needed for other functions. Observers utilized high-powered "big-eye" binoculars (Fujinon, 25x150), hand-held binoculars, and naked eyes to scan from the bow of the ship to approximately 90˚ port and starboard. One member of the team, on a rotating basis, was typically assigned to record data with VisSurv-NE.

When an animal group (porpoise, dolphin, whale, seal, turtle or a few large fish species) was detected, the following data were recorded with VisSurv-NE:

1) Time sighting was initially detected, recorded to the nearest second,
2) Species composition of the group,
3) Radial distance between the team's platform and the location of the sighting, estimated either visually when not using the binoculars or by reticles when using binoculars,
4) Bearing between the line of sight to the group and the ship's track line; measured by a polarus mounted near the observer or a polarus at the base of the binoculars,
5) Best estimate of group size,
6) Direction of swim,
7) Number of calves,
8) Initial sighting cue,
9) Initial behavior of the group, and
10) Any comments on unusual markings or behavior.

Although we recorded marine mammal sightings, we never altered our trackline to collect more information. Because the focus of the survey was to find sea turtles, our survey effort was optimized for turtles rather than standardized line transect data collection; hence our sightings are not appropriate for standard line transect abundance estimates.

In addition to the sightings data, the following effort data were recorded opportunistically:

1) Time of recording
2) Weather conditions: swell direction relative to the ship's travel direction and height (in meters), apparent Beaufort sea state in front of the ship, presence of light or thick haze, rain or fog, amount of cloud coverage, visibility (i.e., approximate maximum distance that can be seen), and glare location and strength of glare within the glare swath (none, slight, moderate, severe).

At the same time, the location (latitude and longitude) of the ship when this information was entered was recorded by the ship's GPS via the ship's sensor SCS system which was connected to the data entry computers.

TURTLE SAMPLING TEAM

When a hardshelled turtle was located, we deployed a work boat (or fast rescue boat) to capture the turtles using a large dipnet. When conditions permitted, we sometimes left the work boat in the water to optimize our response time. All captured turtles were transferred to the NOAA Ship *Henry B. Bigelow* for biological sampling under Dr. Michael James' Canadian licenses.

We completed basic sampling (measured the length and width of captured turtles, photographed, flipper and PIT tagged, and took biopsy samples for genetic analysis); plus we also measured weight and body depth, took biopsy samples for stable isotope analysis, and took blood samples to analyze for testosterone levels (to identify sex) and general blood chemistry (for health assessment).

We used epoxy to attach 2 Sea Mammal Research Unit's (SMRU) Fastloc GPS Satellite Relay Data Logger (SRDL) to a central carapace scute of 2 captured turtles. The SMRU satellite tags were programmed to transmit every day, though local conditions often prevent the tags from transmitting. Specifications for the SMRU Fastloc GPS Satellite Relay Data Loggers (SRDLs) are provided in Appendix E1. The Fastloc GPS supplies highly accurate locations. The tag also uses precision wet/dry, pressure, and temperature sensors to form individual dive (max depth, shape, time at depth, etc.) records along with temperature profiles and binned summary records. We also have custom-made variables to assess the average duration of a surfacing bout and average duration of a diving bout. The SMRU tag stores information in its memory and then relays an unbiased sample of detailed individual dive records and summary records.

PASSIVE ACOUSTIC TEAM

The passive acoustic team consisted of two people who operated the system opportunistically, when the situation allowed for the deployment of the towed hydrophone array. During each shift, one person was designated as the primary data collector with the second person as stand-by.

The towed hydrophone array was deployed during nighttime hours, along the shelf break and offshore, in waters 100 m or greater in depth. The array was comprised of two modular, oil-filled sections (the end-array and in-line array), separated by 30 m of cable. The end-array consisted of 3 “mid-frequency” elements (APC International, 42-1021), 2 “high-frequency” elements (Reson, TC 4013), and a depth sensor (Keller America, PA7FLE). The in-line array consisted of 3 “mid-frequency” elements (APC International, 42-1021). The array was towed 300 m behind the ship. Array depth typically varied between 8 – 12 m when deployed at the typical survey speed of 10 kts. Sound speed data at the tow depth of the array were extracted from morning CTD casts.

Acoustic data from the towed hydrophone array were routed to a custom-built Acoustic Recording System that encompassed all signal conditioning, including A/D conversion, filtering, and gain. Data were filtered at 1000 Hz, and variable gain between 20 – 40 dB was added depending on the relative levels of signal and noise. The recording system incorporated two National Instruments soundcards (NI USB-6356). One soundcard sampled the six mid-frequency channels at 192 kHz, the other sampled the two high-frequency channels at 300 – 500 kHz, both at a resolution of 16 bits. Digitized acoustic data were recorded directly onto laptop and desktop computer hard drives using the software program Pamguard (http://www.pamguard.org/home.shtml), which also recorded simultaneous GPS data, continuous depth data, and allowed manual entry of corresponding notes. Two channels of analog data were also routed to an external RME Fireface 400 soundcard and a separate desktop computer, specifically for the purpose of real-time detection and tracking of vocal animals using the software packages WhalTrak and Ishmael.

OCEANOGRAPHY

During this survey, scientific interest was focused on gelatinous zooplankton in areas where sea turtles were captured. All oceanographic and plankton sampling was opportunistic. Since gelatinous zooplankton is damaged by nets and thus not sampled quantitatively, three imaging systems were deployed in addition to the bongo nets: Video Plankton Recorder (VPR), paired Go-Pro cameras, and a Didson high definition imaging sonar. Other physical water characteristics and distribution and densities of various fish and planktonic trophic levels were documented using Seabird 19+ and 911 CTD, 61cm bongo net, a midwater trawl, and multifrequency Simrad EK60 echosounders. See Appendix H for more details.

Specialized bongo sampling was conducted for Michael Ford (Oceanographer, Marine Ecosystems Division, NOAA Fisheries, Smithsonian Environmental Research Center) targeting gelatinous zooplankton. All gelatinos zooplankton present were measured at sea then the samples were preserved in acid Lugols Solution for further identification.

RESULTS

The scientific personnel are in Table E1 and Figure E2.

UNMANNED AIRCRAFT SYSTEMS (UAS) TEAM

Flight time (portions of three days) was much lower than expected due to health and logistics issues as well as NOAA vessels not being mission-ready. There were also significant challenges associated with the Pumas: computer, navigation, and nadir issues; 2 of 3 payloads did not work; Department of Defense Warning area confusion; and resolution and rewind limitations. Resolution appeared to be acceptable only in optimal conditions.

Although turtles were spotted by visual teams in all of the days that the Puma operated, no transfer of turtle locations from the Puma team to the visual team occurred. This may have been hampered by reduced air time, resolution issues, lack of real time rewind, complications with location labels, or mission novelty. As this was a pioneering mission in many regards, its true contribution will be in how well it helps us to prepare for future missions.

VISUAL TURTLE SIGHTING TEAM

Of the 10 calendar days encompassed by the cruise, 8 were scheduled science days in the study area, with a potential for 192 science hours (based on a 24 hour work schedule). The ship was mission ready for 54% of those hours. The weather prevented or hampered our work in at least 4 of the mission ready days. See Table E2 for a brief summary of the main science activities on each day.

During the on-effort tracklines, the visual team sighted at least 9 cetacean species or species groups, 2 turtle species or species groups, and 4 fish species or species groups (Tables E3 and E4). For cetaceans, the visual team detected 86 groups for a total of 511 individuals. A total of 13 turtles were sighted, as well as several ocean sunfish, manta rays, and tunas (Table E4). Distribution maps of sighting locations of the cetaceans, turtles, and fishes are displayed in Figures E3 – E5.

TURTLE SAMPLING TEAM

We were captured four sea turtles (Table E5). Three of the turtles were loggerheads which were large enough to carry standard satellite tags. We applied two AMAPPS-funded satellite tags to the first two loggerheads captured, and we applied a Canadian-funded satellite tag to the last loggerhead captured. Tracks of the AMAPPS-funded satellite tags (Figure E6) are updated and displayed at http://www.nefsc.noaa.gov/psb/turtles/turtleTracks.html.

PASSIVE ACOUSTIC DETECTION TEAM

Passive acoustic data were collected using the towed hydrophone array during three evenings, for a total of 17.5 hrs. Towed array data collection covered approximately 332 km. Data were post-processed to identify all acoustic detections of beaked whales (Figure E7). There were 16 definite acoustic detections of beaked whales, the majority of which were Cuvier's beaked whales (Table E6).

The high-frequency acoustic recording package (HARP) was deployed on 26 June 2015, at approximately 41.06ºN 66.35ºW (Figure E7, site 1).

OCEANOGRAPHY

For more details see Appendix H. In brief, the following was collected:

- Environmental variables collected via the ship's onboard sensors (Table D6 in Appendix D this document).
- Video data from 8 Didson and 16 Go-Pro deployments.
- VPR data from 5 VPR hauls.
- Bongo and CTD tows were deployed 6 times.

DISPOSITION OF THE DATA

All visual and passive acoustic data collected will be maintained by the Protected Species Branch at the Northeast Fisheries Science Center (NEFSC) in Woods Hole, MA. Visual sightings data have been archived in the NEFSC's Oracle database.

All hydrographic data collected are maintained by the Fishery Oceanography Branch at the NEFSC in Woods Hole, MA. Hydrographic data can be accessed through the Oceanography web site http://www.nefsc.noaa.gov/epd/ocean/MainPage/ioos.html or the NEFSC's Oracle database. VPR data are stored by the NEFSC Oceanography Branch and available by request.

Plankton samples which were not transferred to Michael Ford will be maintained by the Fishery Oceanography Branch (at the NEFSC in Narragansett RI) and may be sent to Poland for identification. Plankton data will become accessible through the NEFSC's Oracle database after they are processed.

Didson and Go-Pro zooplankton image samples are being stored and processed by the Coonamessett Farm Association.

All active acoustic data are archived and maintained by the NEFSC Data Management Services (DMS) branch at the NEFSC. In addition, all EK60 data are archived and maintained at NOAA's NGDC in Boulder, CO.

PERMITS

This research was authorized under the US Permit No. 16556 issued to the NEFSC and the Canadian Permit No. M-15-07 issued to Dr. Michael James.

ACKNOWLEDGEMENTS

The funds for this project came from the Bureau of Ocean Energy Management (BOEM) and the US Navy through the respective Interagency Agreements for the AMAPPS project. Staff time was provided for by Coonamessett Farm Foundation, the NOAA OAR UAS program, and the NOAA Fisheries Service, Northeast Fisheries Science Center (NEFSC), Protected Species Branch, Oceanography Branch, and Behavioral Ecology Branch.

Appendix E1

Software specification for FA_15A deployment
(Loggerhead GPS Argos)

Valid for dates in years 2015 to 2018

Transmitting via ARGOS
Argos page transmission sequences:

Until day 150: 0 1 2 1 3 4 1 2 3 0 1 2 3 0 1 2 3 1 3 1

Until day 1464: 0 1 3 1 3 4 1 3 1 3 0 1 3 0 3 1 3 1 3 1
An additional diagnostics page (5) is sent every 60 transmissions

Argos airtest for up to 17 hours:
Transmission interval is chosen randomly between 48 and 72 seconds

Satellite availability (UTC):
00: -- on --
01: -- on --
02: -- on --
03: -- on --
04: -- on --
05: -- on --
06: -- on --
07: -- on --
08: -- on --
09: -- on --
10: -- on --
11: -- on --
12: -- on --
13: -- on --
14: -- on --
15: -- on --
16: -- on --
17: -- on --
18: -- on --
19: -- on --
20: -- on --
21: -- on --
22: -- on --
23: -- on --

Transmission targets:

70000 transmissions after 200 days

Normal interval between Argos transmissions: 44 secs
In Haulouts: ON (one tx every 44 secs) for first 1 day

then cycling OFF for 0, ON for 1 day

Check sensors every 4 secs
When near surface (shallower than 6m), check wet/dry every 1 sec
Consider wet/dry sensor failed if wet for 30 days or dry for 99 days
Dives start when wet and below 1.5m for 20 secs
and end when dry, or above 1.5m
Do not separate 'Deep' dives
No cruises
A haulout begins when dry for 6 mins
and ends when wet for 40 secs

Dive shape (normal dives):
5 points per dive using broken-stick algorithm

Dive shape (deep dives):
none

CTD profiles: max 250 dbar up to 2 dbar in 1 dbar bins.
Note: these values should now be given in cbar. They have been auto-converted from dbar because CTD_HI_RES_PRESSURE is not specified

Temperature: Collected, Stored.
Conductivity: Not collected.
Salinity: Not collected.
Fluorescence: Not collected.
Oxygen: Not collected.
Light level: Not collected.
Construct a single profile for each 4-hour period.
During profile, sample CTD sensor every 4 seconds when deeper than 2500 m, every 4 seconds when shallower than 2500 m.
Each profile contains 10 cut points
consisting of 0 fixed points, minimum depth, maximum depth, 8 broken-stick points

GPS fixes:
Number of GPS attempts allowed: unlimited
Cut-off date for GPS attempts: 150 days (then increase interval to 0x normal)
Discard results with fewer than 5 satellites
Haulouts: Increase interval to 12x normal after first success in haulout

TRANSMISSION BUFFERS (in RAM):
Dives in groups of 2 (2.22222 days @ 15 dives/hour): 400 = 1600 bytes
No 'deep' dives
Haulouts: 30 = 120 bytes
6-hour Summaries in groups of 1 (10 days): 40 = 160 bytes
No Timelines
No Cruises
No Diving periods
No Spot depths
No Emergence records
No Dive duration histograms

No Max depth histograms
6-hour Depth & Temperature histograms in groups of 1 (10 days): 40 = 160 bytes
CTD casts (8.33333 days): 50 = 200 bytes
GPS fixes (variable: 35.4167 days if interval is 10 mins): 5100 = 20400 bytes
No Spot CTD's
No Vemco VMT's

TOTAL 22640 bytes (of about 21000 available)

MAIN BUFFERS (in 24 Mb Flash):
Dive in groups of 2 (2.22222 days @ 15 dives/day): 400 x 144 bytes = 57600 bytes
No 'deep' dives
Haulout: 30 x 32 bytes = 960 bytes
6-hour summaries in groups of 1 (10 days): 40 x 88 bytes = 3520 bytes
6-hour Depth & Temperature histograms in groups of 1 (10 days): 40 x 32 bytes = 1280 bytes
No timelines
No cruises
No diving periods
No spot depths
No emergence records
No Duration histograms
No Max depth histograms
CTD casts (8.33333 days): 50 x 64 bytes = 3200 bytes
GPS fixes (variable: 35.4167 days if interval is 10 mins): 5100 x 152 bytes = 775200 bytes
No spot CTD's
No Vemco VMT's

TOTAL 822 kb (from 8192 kb available)

PAGE CONTENTS:

PAGE 0 (Argos, 247 bits):

PTT NUMBER OVERHEAD (28-bit code)
-----------[8 bits: 0 - 7]

PAGE NUMBER
-----------[3 bits: 8 - 10]

DIVE group in format 0:
Normal dives transmitted in groups of 2
Time of start of last dive: max 7 days 12 hours @ 10 secs= 64800
tx as raw 16 bits in units of 1 (range: 0 to 65535) OK
(recommended sell-by 7 days 11 hours, actual: 7 days 6 hours is OK)
Number of records: raw 2 bits in units of 1 (range: 0 to 3)
Reason for end: -- not transmitted --
Group number: -- not transmitted --
Max depth: -- not transmitted --
Dive duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
Mean speed: -- not transmitted --
Profile data (5 depths/times, 0 speeds):

Depth profile: Lookup with 64 bins: <1,1-2,2-3,3-4,4-5,5-6,6-7,7-8,8-9,9-10,10-11,11-12,12-13,13-14,14-15,15-16,16-17,17-18,18-19,19-20,20-22,22-24,24-26,26-28,28-30,30-32,32-34,34-36,36-38,38-40,40-42,42-44,44-46,46-48,48-50,50-52,52-54,54-56,56-58,58-60,60-62,62-64,64-66,66-68,68-70,70-75,75-80,80-85,85-90,90-95,95-100,100-110,110-120,120-130,130-140,140-150,150-160,160-170,170-180,180-190,190-200,200-220,220-240, >240 in units of 0.1 m (range: 0 to 240 m)

Profile times: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)

Speed profile: -- not transmitted --

Temperature : -- not transmitted --

Light : -- not transmitted --

Residual: -- not transmitted --

Calculation time: -- not transmitted --

Surface duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)

Dive area: raw 9 bits in units of 2 permille (range: 0 to 1022 permille)

-----------[236 bits: 11 - 246]

Available bits used exactly

=== End of page 0 ===

PAGE 1 (Argos, 247 bits):

PTT NUMBER OVERHEAD (28-bit code)

-----------[8 bits: 0 - 7]

PAGE NUMBER

-----------[3 bits: 8 - 10]

SUMMARY group in format 0:

Transmitted in groups of 1

Record could be in buffer for 10 days

End time: max 10 days 6 hours @ 1 hour= 246

tx as raw 8 bits in units of 1 (range: 0 to 255) OK

(recommended sell-by 10 days 5 hours, actual: 10 days is OK)

Number of records: raw 1 bits in units of 1 (range: 0 to 1)

Cruising time: -- not transmitted --

Haulout time: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)

Dive time: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)

Deep Dive time: -- not transmitted --

Normal dives:

Avg max dive depth: Lookup with 64 bins: <1,1-2,2-3,3-4,4-5,5-6,6-7,7-8,8-9,9-10,10-11,11-12,12-13,13-14,14-15,15-16,16-17,17-18,18-19,19-20,20-22,22-24,24-26,26-28,28-30,30-32,32-34,34-36,36-38,38-40,40-42,42-44,44-46,46-48,48-50,50-52,52-54,54-56,56-58,58-60,60-62,62-64,64-66,66-68,68-70,70-75,75-80,80-85,85-90,90-95,95-100,100-110,110-120,120-130,130-140,140-150,150-160,160-170,170-180,180-190,190-200,200-220,220-240, >240 in units of 0.1 m (range: 0 to 240 m)

SD max dive depth: Lookup with 64 bins: <1,1-2,2-3,3-4,4-5,5-6,6-7,7-8,8-9,9-10,10-11,11-12,12-13,13-14,14-15,15-16,16-17,17-18,18-19,19-20,20-22,22-24,24-26,26-28,28-30,30-32,32-34,34-36,36-38,38-40,40-42,42-44,44-46,46-48,48-50,50-52,52-54,54-56,56-58,58-60,60-62,62-64,64-66,66-68,68-70,70-75,75-80,80-85,85-90,90-95,95-100,100-110,110-120,120-130,130-140,140-150,150-160,160-170,170-180,180-190,190-200,200-220,220-240, >240 in units of 0.1 m (range: 0 to 240 m)

Max max dive depth: Lookup with 64 bins: <1,1-2,2-3,3-4,4-5,5-6,6-7,7-8,8-9,9-10,10-11,11-12,12-13,13-14,14-15,15-16,16-17,17-18,18-19,19-20,20-22,22-24,24-26,26-28,28-30,30-

32,32-34,34-36,36-38,38-40,40-42,42-44,44-46,46-48,48-50,50-52,52-54,54-56,56-58,58-60,60-62,62-64,64-66,66-68,68-70,70-75,75-80,80-85,85-90,90-95,95-100,100-110,110-120,120-130,130-140,140-150,150-160,160-170,170-180,180-190,190-200,200-220,220-240, >240 in units of 0.1 m (range: 0 to 240 m)

Avg dive duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
SD dive duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
Max dive duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
Avg surface duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
SD surface duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
Max surface duration: odlog 3/7 in units of 4 s (range: 0 to 130302 s)
Avg speed in dive: -- not transmitted --
Number of dives: odlog 2/4 in units of 1 (range: 0 to 235.5)

Deep dives:

Avg max dive depth: -- not transmitted --
SD max dive depth: -- not transmitted --
Max max dive depth: -- not transmitted --
Avg dive duration: -- not transmitted --
SD dive duration: -- not transmitted --
Max dive duration: -- not transmitted --
Avg surface duration: -- not transmitted --
SD surface duration: -- not transmitted --
Max surface duration: -- not transmitted --
Avg speed in dive: -- not transmitted --
Number of dives: -- not transmitted --

Avg SST: -- not transmitted --
-----------[113 bits: 11 - 123]

DEPTH & TEMPERATURE histogram group in format 0:

Histogram with 5 depth bins:
Transmitted in groups of 1
Record could be in buffer for 10 days
End time: max 10 days 6 hours @ 1 hour= 246
tx as raw 8 bits in units of 1 (range: 0 to 255) OK
(recommended sell-by 10 days 5 hours, actual: 10 days is OK)
Number of records: raw 1 bits in units of 1 (range: 0 to 1)

Max. max depth: -- not transmitted --
Dry temperature: -- not transmitted --
Dry usage: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Surface temperature: -- not transmitted --
Surface usage (< 1 m): raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
5 depth bins:
Depth band temperature: -- not transmitted --
Usage of depths 1 to 2 m: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Usage of depths 2 to 3 m: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Usage of depths 3 to 4 m: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
Usage of depths 4 to 5 m: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)

Usage of depths 5 to 2999 m: raw 10 bits in units of 1 permille (range: 0 to 1023 permille)
-----------[79 bits: 124 - 202]

DIAGNOSTICS in format 0:

GPS zero satellites: wraparound 13 bits in units of 1 (range: 0 to 8191)
GPS 1-4 satellites: wraparound 13 bits in units of 1 (range: 0 to 8191)
GPS 5 or more satellites: wraparound 13 bits in units of 1 (range: 0 to 8191)
GPS reboots: wraparound 5 bits in units of 1 (range: 0 to 31)
-----------[44 bits: 203 - 246]

Available bits used exactly
=== End of page 1 ===

PAGE 2 (Argos, 247 bits):
PTT NUMBER OVERHEAD (28-bit code)
-----------[8 bits: 0 - 7]

PAGE NUMBER
-----------[3 bits: 8 - 10]

GPS in format 1:

Timestamp: max 3 days @ 1 sec= 259200
tx as raw 18 bits in units of 1 (range: 0 to 262143) OK
(recommended sell-by 2 days 23 hours, actual: 2 days 21 hours is OK)
n_sats: raw 3 bits in units of 1 (range: 5 to 12)
GPS mode: -- not transmitted --
Best 8 satellites:
Sat ID's: raw 5 bits in units of 1 (range: 0 to 31)
Pseudorange: raw 15 bits in units of 1 (range: 0 to 32767)
Signal strength: -- not transmitted --
Doppler: -- not transmitted --
Max signal strength: -- not transmitted --
Noisefloor: -- not transmitted --
Max CSN (x10): -- not transmitted --
-----------[181 bits: 11 - 191]

HAULOUT in format 0:
Number of records: raw 1 bits in units of 1 (range: 0 to 1)
Haulout number: wraparound 5 bits in units of 1 (range: 0 to 31)
Start time: max 21 days 12 hours @ 2 mins= 15480
tx as raw 14 bits in units of 1 (range: 0 to 16383) OK
(recommended sell-by 21 days 11 hours, actual: 21 days is OK)
End time: max 21 days 12 hours @ 2 mins= 15480
tx as raw 14 bits in units of 1 (range: 0 to 16383) OK
(recommended sell-by 21 days 11 hours, actual: 21 days is OK)
Duration: -- not transmitted --
cf. Max duration is 1 day
Reason for end: -- not transmitted --

Contiguous: -- not transmitted --
-----------[34 bits: 192 - 225]

DIAGNOSTICS in format 1:

TX number: wraparound 14 bits in units of 5 (range: 0 to 81915)
Driest (max wet/dry): raw 7 bits in units of 2 (range: 0 to 254)
-----------[21 bits: 226 - 246]

Available bits used exactly
=== End of page 2 ===

PAGE 3 (Argos, 247 bits):
PTT NUMBER OVERHEAD (28-bit code)
-----------[8 bits: 0 - 7]

PAGE NUMBER
-----------[3 bits: 8 - 10]

GPS in format 0:

Timestamp: max 382 days @ 1 sec= 33004800
tx as raw 25 bits in units of 1 (range: 0 to 3.35544e+07) OK
(recommended sell-by 381 days 23 hours, actual: 380 days is OK)
n_sats: raw 3 bits in units of 1 (range: 5 to 12)
GPS mode: -- not transmitted --
Best 8 satellites:
Sat ID's: raw 5 bits in units of 1 (range: 0 to 31)
Pseudorange: raw 15 bits in units of 1 (range: 0 to 32767)
Signal strength: -- not transmitted --
Doppler: -- not transmitted --
Max signal strength: -- not transmitted --
Noisefloor: -- not transmitted --
Max CSN (x10): -- not transmitted --
-----------[188 bits: 11 - 198]

HAULOUT in format 0:
Number of records: raw 1 bits in units of 1 (range: 0 to 1)
Haulout number: wraparound 5 bits in units of 1 (range: 0 to 31)
Start time: max 21 days 12 hours @ 2 mins= 15480
tx as raw 14 bits in units of 1 (range: 0 to 16383) OK
(recommended sell-by 21 days 11 hours, actual: 21 days is OK)
End time: max 21 days 12 hours @ 2 mins= 15480
tx as raw 14 bits in units of 1 (range: 0 to 16383) OK
(recommended sell-by 21 days 11 hours, actual: 21 days is OK)
Duration: -- not transmitted --
cf. Max duration is 1 day
Reason for end: -- not transmitted --
Contiguous: -- not transmitted --
-----------[34 bits: 199 - 232]

DIAGNOSTICS in format 2:

TX number: wraparound 14 bits in units of 5 (range: 0 to 81915)
-----------[14 bits: 233 - 246]

Available bits used exactly
=== End of page 3 ===

PAGE 4 (Argos, 247 bits):
PTT NUMBER OVERHEAD (28-bit code)
-----------[8 bits: 0 - 7]

PAGE NUMBER
-----------[3 bits: 8 - 10]

CTD PROFILE in format 0:

End time: max 7 days 12 hours @ 4 hours= 45
tx as raw 6 bits in units of 1 (range: 0 to 63) OK
(recommended sell-by 7 days 11 hours, actual: 7 days is OK)
CTD cast number: -- not transmitted --
Note: these old-style dbar pressures are internally converted to cbar
Min pressure: -- not transmitted --
Max pressure: raw 8 bits in units of 1 dbar (range: 2 to 257 dbar)
Min temperature: raw 12 bits in units of 0.01 (range: 0 to 40.95 = -5 to 35.95 °C in steps of 0.01 °C)
Max temperature: raw 12 bits in units of 0.01 (range: 0 to 40.95 = -5 to 35.95 °C in steps of 0.01 °C)
Number of samples: -- not transmitted --
10 profile points 0 to 9 (from total of 10 cut points):
Temperature:
Min pressure is sent separately
Max pressure is sent separately
8 broken stick pressure bins: raw 8 bits in units of 1 bin (range: 0 to 255 bin)
10 x Temperature: raw 8 bits in units of 3.92157 permille (range: 0 to 1000 permille)
Temperature residual: -- not transmitted --
Temperature bounds : -- not transmitted --
Conductivity bounds : -- not transmitted --
Salinity bounds : -- not transmitted --
Min DOxy: -- not transmitted --
Max DOxy: -- not transmitted --
Min fluoro: -- not transmitted --
Max fluoro: -- not transmitted --
Min Light: -- not transmitted --
Max Light: -- not transmitted --
-----------[182 bits: 11 - 192]

HAULOUT in format 0:
Number of records: raw 1 bits in units of 1 (range: 0 to 1)

Haulout number: wraparound 5 bits in units of 1 (range: 0 to 31)
Start time: max 21 days 12 hours @ 2 mins= 15480
tx as raw 14 bits in units of 1 (range: 0 to 16383) OK
(recommended sell-by 21 days 11 hours, actual: 21 days is OK)
End time: max 21 days 12 hours @ 2 mins= 15480
tx as raw 14 bits in units of 1 (range: 0 to 16383) OK
(recommended sell-by 21 days 11 hours, actual: 21 days is OK)
Duration: -- not transmitted --
cf. Max duration is 1 day
Reason for end: -- not transmitted --
Contiguous: -- not transmitted --
-----------[34 bits: 193 - 226]

DIAGNOSTICS in format 3:

ADC offset: raw 6 bits in units of 25 A/D units (range: 0 to 1575 A/D units)
Max depth ever: raw 7 bits in units of 5 m (range: 0 to 635 m)
Driest (max wet/dry): raw 7 bits in units of 2 (range: 0 to 254)
-----------[20 bits: 227 - 246]

Available bits used exactly
=== End of page 4 ===

PAGE 5 (special diagnostics page sent every 60 transmissions)
PTT NUMBER OVERHEAD (28-bit code)
-----------[8 bits: 0 - 7]

PAGE NUMBER
-----------[3 bits: 8 - 10]

TX number: wraparound 18 bits in units of 1 (range: 0 to 262143)
Current state: raw 3 bits in units of 1 (range: 0 to 7)
Tag time (mm:ss): raw 12 bits in units of 1 secs (range: 0 to 4095 secs)
ADC offset: raw 12 bits in units of 1 A/D units (range: 0 to 4095 A/D units)
Tag hours: wraparound 16 bits in units of 1 hours (range: 0 to 65535 hours)
Wet/dry status: raw 2 bits in units of 1 (range: 0 to 3)
Wet/dry fail count: wraparound 8 bits in units of 1 (range: 0 to 255)
Body number: raw 16 bits in units of 1 (range: 0 to 65535)
Max depth ever: raw 15 bits in units of 0.1 m (range: 0 to 3276.7 m)
Latest reset hour: raw 16 bits in units of 1 hours (range: 0 to 65535 hours)
Number of resets: wraparound 8 bits in units of 1 (range: 0 to 255)
Wettest (min wet/dry): raw 8 bits in units of 1 (range: 0 to 255)
Driest (max wet/dry): raw 8 bits in units of 1 (range: 0 to 255)
GPS zero satellites: wraparound 14 bits in units of 1 (range: 0 to 16383)
GPS 1-4 satellites: wraparound 14 bits in units of 1 (range: 0 to 16383)
GPS 5 or more satellites: wraparound 14 bits in units of 1 (range: 0 to 16383)
GPS reboots: wraparound 4 bits in units of 1 (range: 0 to 15)
Number of depth spikes: wraparound 8 bits in units of 1 (range: 0 to 255)
Number of CTD samples: wraparound 22 bits in units of 1 (range: 0 to 4.1943e+06)
-----------[218 bits: 11 - 228]

UNUSED
-----------[18 bits: 229 - 246]

=== End of page 5 ===

Table E1. Scientific personnel involved in the HB15-03 survey Leg 2. FN = Foreign National.

Personnel	Title	Organization
Haas, Heather	Chief Scientist	NOAA NEFSC, Woods Hole, MA
Broughton, Elisabeth	Oceanography Lead	NOAA NEFSC, Woods Hole, MA
Haver, Samara	Turtle / Acoustic	Integrated Statistics, Woods Hole, MA
Hoffman, Paul	Puma monitor	NOAA Aircraft Operations Center
Izzi, Annamaria	Acoustics lead	Integrated Statistics, Woods Hole, MA
Jacobs, Todd	Puma lead	NOAA OAR UAS Program
James, Mike (FN)	Turtle ecologist	Fisheries and Oceans Canada
Kellog, Loren	Small boat operator	Integrated Statistics, Woods Hole, MA
Matzen, Eric	Lead for small boat ops	Integrated Statistics, Woods Hole, MA
Miller, Shea	Turtle ecologist	Coonamessett Farm Foundation, MA
Milliken, Henry	Small boat operator	NOAA NEFSC, Woods Hole, MA
Patel, Samir	Turtle ecologist	Coonamessett Farm Foundation, MA
Rogers, Mark	Puma UAS Pilot/PIC	NOAA UAS Office

Table E2. Summary of daily activities during HB15-03 Leg 2.

Date	Brief summary of main science activities
23 June	Waited out a storm at dock and then waited overnight for Ship's crew to come on duty for a morning departure. While at dock we practiced small boat deployments.
24 June	Transited from Newport south towards the shelf break and practiced small boat operations. Passive acoustic operations at night.
25 June	Puma in air, small boat in water. Good weather in am, no turtles sighted. Passive acoustic operations at night.
26 June	Small boat not working; steamed to HARP location, deployed HARP, did oceanographic transect through warm core ring. Passive acoustic operations at night.
27 June	Good weather day; Puma in air, used fast rescue boat with limitations; caught 2 turtles. Stopped science to depart for Boston at 3:30pm; no passive acoustic operations.
28 June	Arrive Boston in afternoon. No passive acoustic operations.
29 June	Depart Boston to transit to Georges Bank. No passive acoustic operations.
30 June	Arrive Georges Bank at dawn. Flew Puma. Caught 2 turtles.
1 July	Puma flights in morning. Turtles sighted. Deteriorating weather, did oceanographic transect. Stopped science to depart for Newport. No passive acoustic operations.
July 2	Arrive Newport in am.

Table E3. Number of groups and individuals of cetacean species detected by the visual observers during the survey.

Species		Number of groups	Number of individuals
Atlantic spotted dolphin	*Stenella frontalis*	1	6
Bottlenose dolphin	*Tursiops truncatus*	5	52
Common dolphin	*Delphinus delphis*	10	69
Fin whale	*Balaenoptera physalus*	13	15
Fin/sei whales	*B. physalus or B. borealis*	4	6
Pilot whales spp.	*Globicephala spp.*	8	56
Risso's dolphin	*Grampus griseus*	9	37
Sei whale	*Balaenoptera borealis*	1	1
Sperm whale	*Physeter macrocephalus*	6	10
Striped dolphin	*Stenella coeruleoalba*	1	50
Unid. dolphin	*Delphinidae*	21	200
Unid. large whale	*Mysticeti*	7	9
TOTAL CETACEANS		**86**	**511**

Table E4. Number of groups and individuals of large fish and turtles detected by the visual observers during the survey.

Species		Number of groups	Number of individuals
Manta rays spp.	*Manta spp.*	2	2
Ocean sunfish	*Mola mola*	3	4
Shark spp.		1	1
Tuna spp.		2	2
Leatherback turtle	*Dermochelys coriacea*	3	3
Loggerhead turtle	*Caretta caretta*	8	8
Unid hardshell turtle	*Chelonioidea*	2	2
TOTAL ALL SPECIES		**21**	**10**

Table E5. Information on captured turtles.

Date	Latitude	Longitude	Species	Curved Carapace Length	Type of Tags
Jun 27	41° 10.73’	65° 31.91’	loggerhead	73.1	Left and right rear flipper, PIT, and SMRU satellite tags
Jun 27	41° 10.48’	65° 40.43’	loggerhead	67.0	Left and right rear flipper, PIT, and SMRU satellite tags
Jun 30	41° 24.32’	65° 10.30	Kemp’s ridley	30.5	PIT tag
Jun 30	41° 21.26’	65° 14.08	loggerhead	55.8	Left and right rear flipper, PIT, Canadian satellite, and Vemco tags

Table E6. Summary of acoustic detections of individual beaked whales during HB15-03 Leg 2. Towed array data were collected for approximately 17.5 hrs during the survey, covering 33 km. Acoustic detections of beaked whales are classified as “definite”, “probable”, or “possible”, based on the spectral and temporal characteristics of the echolocation clicks and the entire acoustic event.

Species	Total	Definite	Probable	Possible
Cuvier’s beaked whale	18	11	1	6
Gervais’ beaked whale	11	4	1	6
UNID Mesoplodont	4	1	2	1
Total	**33**	**16**	**4**	**13**

Figure E1. Survey area covered during HB15-03 Leg 2. The US exclusive economic zone (EEZ) and the 100 m, 200 m, 1000 m and 2000m depth contours are also displayed.

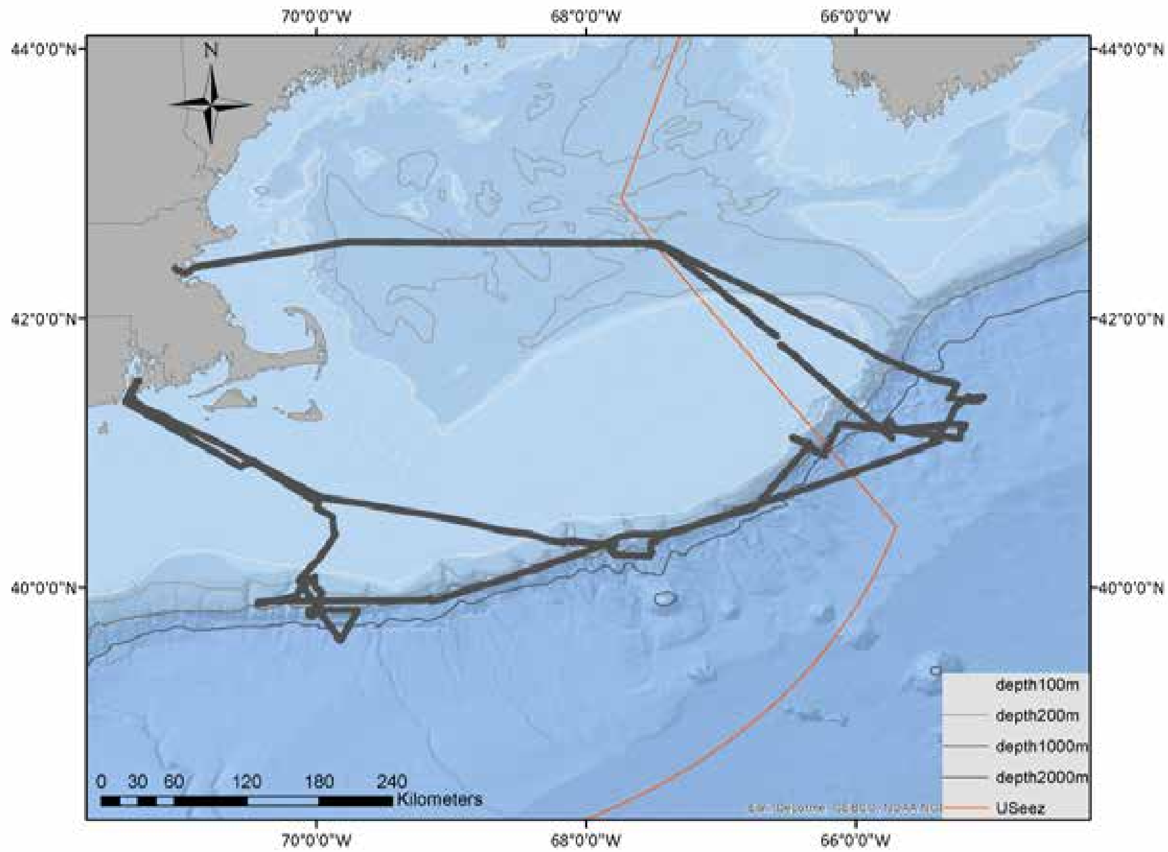


Figure E2. Organization of scientific staff into teams.

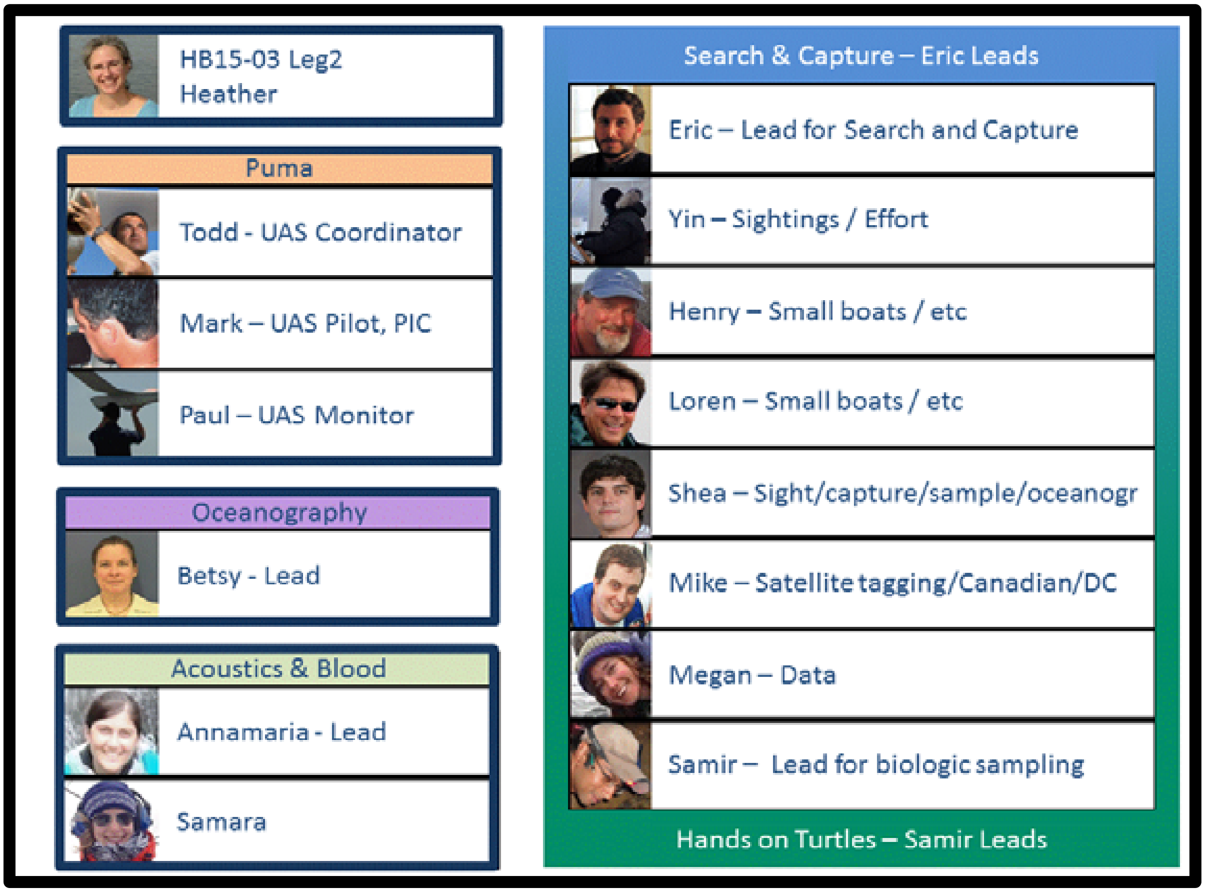


Figure E3. Location of large whale sightings during HB15-03 Leg 2.

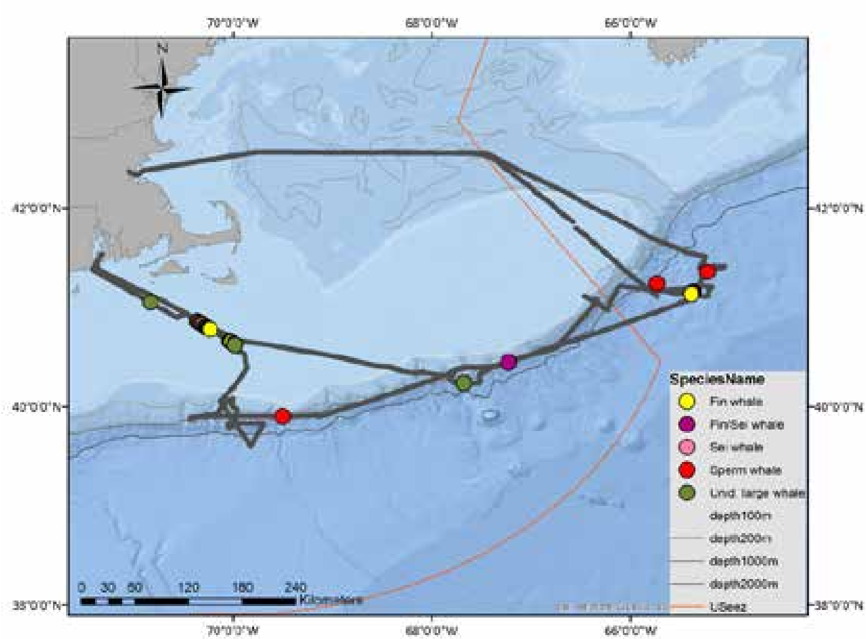


Figure E4. Location of delphinid sightings during HB15-03 Leg 2.

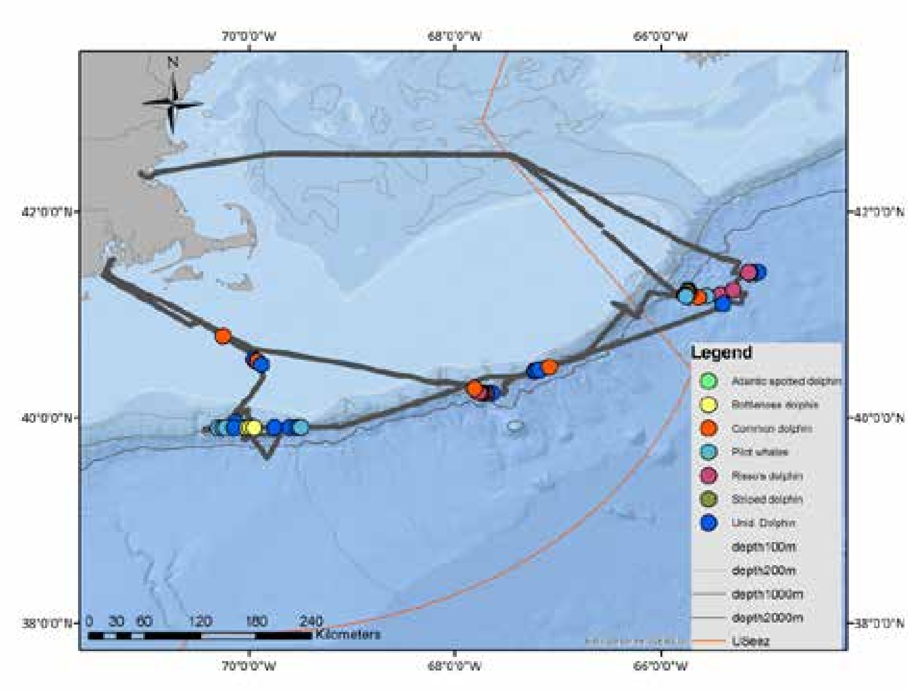


Figure E5. Location of sharks, rays and turtles sighted during HB15-03 Leg 1.

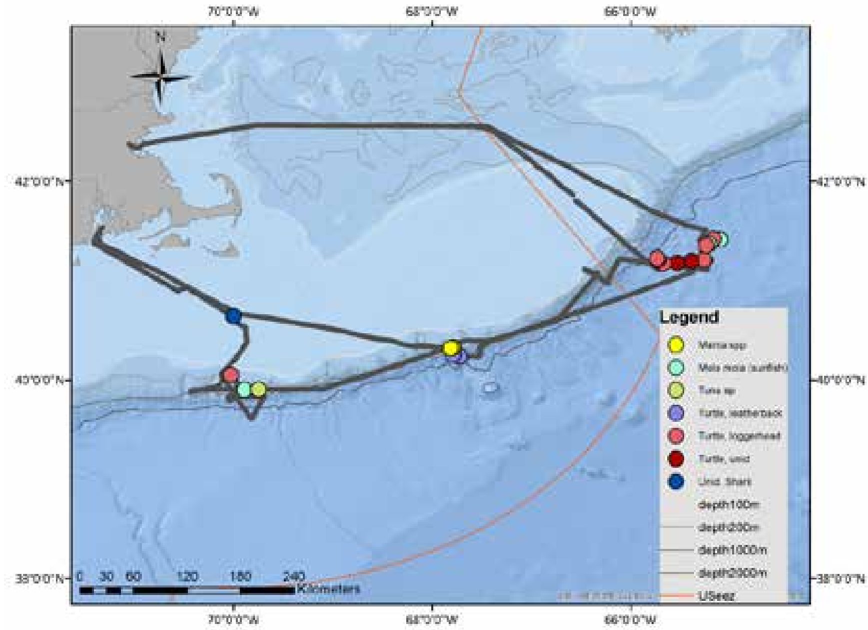


Figure E6. Tracks of the two loggerheads with AMAPPS-funded satellite tags.

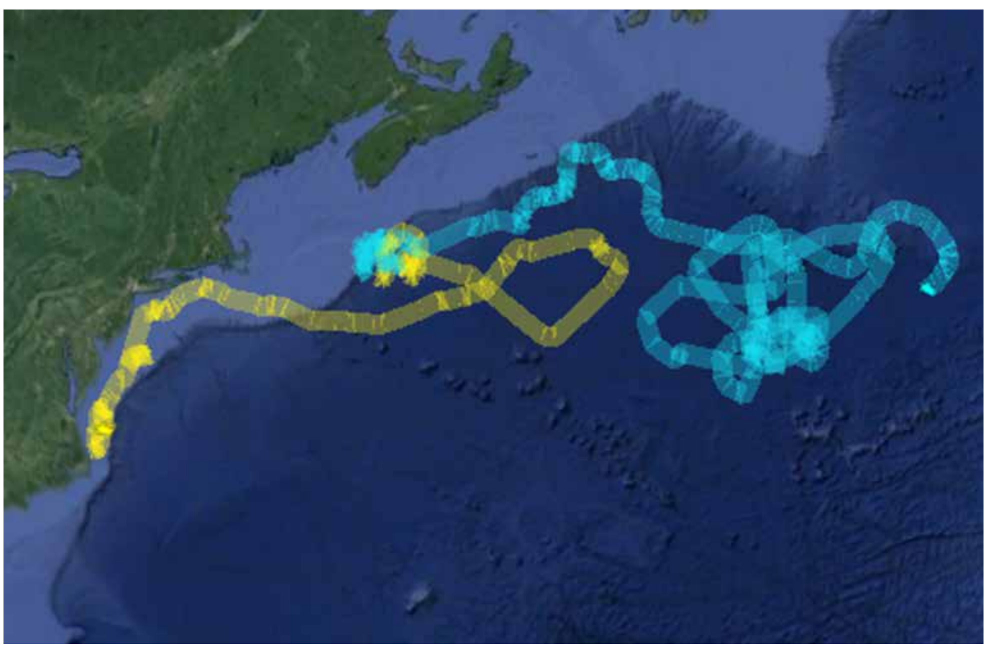
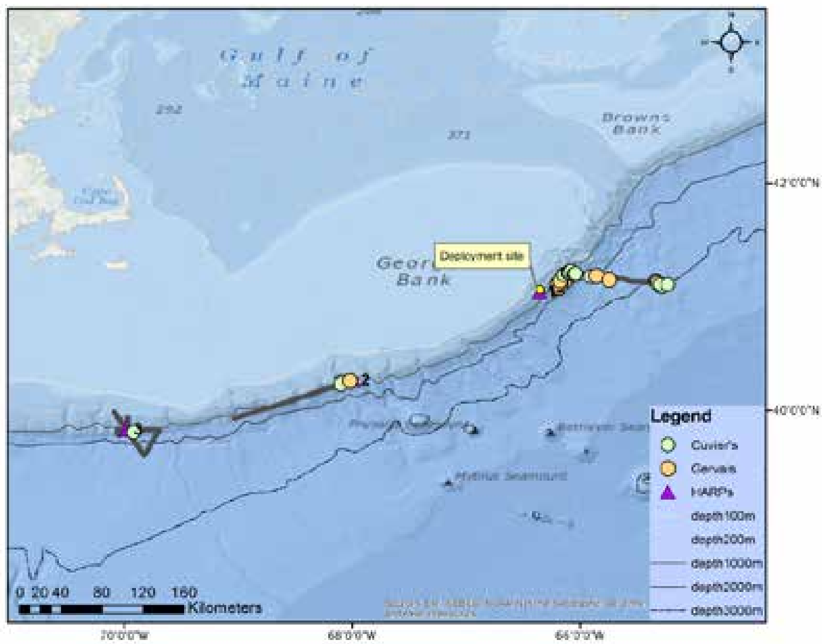


Figure E7. Map showing areas where the towed hydrophone array was deployed (gray lines) and the corresponding acoustic detections of beaked whales. Green dots indicate detections of Cuvier's beaked whales; orange dots indicate Gervais' beaked whales. The magenta triangles show the positions of HARP (high-frequency acoustic recording package) deployments. Site 1 was deployed during Leg 2 of this survey; sites 2 & 3 had been deployed previously.



Appendix F: *Progress on processing input data and developing density models and maps: Northeast and Southeast Fisheries Science Centers*

Samuel Chavez[1], Lance Garrison[2], Joseph Godelick[3], Joshua Hatch[1], Elizabeth Josephson[1], Kimberly Murray[3], Christopher Orphanides[4], Debra Palka[3], Doug Sigourney[1], Melissa Warden[1]

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SUMMARY

To develop animal density models incorporating environmental data, during 2015 we accomplished the following: further explored the sightings data; added sea surface height anomaly as an additional dynamic variable to be used in the habitat models; assessed the accuracy of the remotely-sensed environmental data values of several satellite-derived and HYCOM ocean model-derived environmental variables as compared to in-situ values of measured variables across the Northeast study region; improved the estimation of average surface and dive time of the tag data; and further developed the two frameworks to model the spatial/temporal distribution of marine mammals and sea turtles: generalized additive models and Bayesian hierarchical models. Preliminary versions of these two frameworks were reviewed by peers in February 2015. In addition, to improve the accuracy of the visual teams' distance measurements, a NEFSC engineer is collaborating with AMAPPS to develop an electronic range finder.

INTRODUCTION

One of the objectives of the AMAPPS project is to develop spatially- and temporally-explicit density maps of marine mammals, sea turtles, and sea birds that incorporate environmental variables. To achieve this objective, the Northeast Fisheries Science Center (NEFSC) and Southeast Fisheries Science Center (SEFSC) are continuing to develop a Generalized Additive Modeling (GAM) framework and a hierarchical Bayesian framework.

During 2015 work continued on projects related to both of these frameworks, in addition to work specific to each framework. The statistical methods behind the frameworks and preliminary results were reviewed by 19 colleagues in February 2015. Papers made available before a webinar describing the input data, statistical methods, and preliminary results. The webinar summarized the papers and provided time for questions, discussions and recommendations for improvements. Reviewers provided comments both during the webinar and in writing. These comments were then incorporated into updated version of the frameworks.

This appendix will briefly provide a progress report of the work conducted in 2015 that relates to the estimation of the density maps.

RESULTS

WORK RELATED TO BOTH FRAMEWORKS

Survey data

During 2015 these data were further QA/QC'd, where a few minor errors were corrected.

Environmental data

During 2015 an additional dynamic variable was added, the sea surface height anomaly, which was sourced from the Delayed-Time Mean Sea Level Anomaly product (DT MSLA "all sat merged") provided by AVISO. These altimetry products were produced by Ssalto/*Duacs* and distributed by *Aviso*, with support from *Cnes* (http://www.aviso.altimetry.fr/duacs/).

For all the dynamic environmental data the process of filling in missing variables within the AMAPPS study area was refined. A hierarchical interpolation process was used to replace missing values. The hierarchy for the sources of replacement values was, first, the calculated mean from the nearest-neighbor grid cells with non-missing data from the same 8-day period of interest. Then if that was not sufficient, the mean value for the grid cell of interest for the 8-day period before and after was used to fill in the missing value in the grid cell of interest.

To assess the accuracy of the remotely-sensed environmental data, values of several satellite-derived and HYCOM ocean model-derived environmental variables were compared to in-situ values of measured variables across the Northeast study region (Maine to North Carolina). In-situ values of sea surface temperature, bottom temperature (collected within 10 m of the ocean floor), surface salinity, and mixed layer depth measured via over 1500 casts of a conductivity, temperature, depth (CTD) probe from eight NOAA research cruises during February to November 2013 were compared to corresponding values of the remotely-sensed environmental data at the same geographic position and time period. The comparisons were made across the entire spatial and temporal domain, and also by month across a 1° latitude and longitude grid. In addition, box plots by month depicted the spread of differences between the remotely-sensed value and the CTD value. In general this comparison showed satellite sea surface temperature was very closely aligned with the in-situ values, the modeled remotely-sensed bottom temperature was moderately aligned, while salinity and mixed layer depth were only fairly aligned.

Dive data

Dive time patterns are used to correct the density estimates derived from survey data where there are high chances of missing a group of animals that are close to the track line because the animal spends a long time under the surface. This is particularly needed for long-diving species detected during the aerial surveys; such as, species like sea turtles, sperm whales, and beaked whales. The data needed to develop the correction factor are the average time spent at the surface and below the surface, and the area where animal could be seen from the survey platform (viewing radius).

During 2015, the statistical analyses of the DTAG data used to obtain the average surface and dive times of fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*), blue whales (*Balaenoptera musculus*), Cuvier's beaked whales (*Ziphius cavirostris*), Baird's beaked whales (*Berardius bairdii*), pilot whales (*Globicephala spp.*), and Risso's dolphins (*Grampus griseus*) were refined. Smoothed running averages over 21 sec (10 sec before and after each reading) were calculated and modeled using random effects to account for the fact that multiple readings were recorded for the same individual when estimating the average surface or dive times.

Average surface and time times of species for which DTAG data were not available were obtained from the literature. In addition, the 2010 – 2014 NEFSC aerial survey data were investigated to obtain species-specific viewing radius values. Then all these data were inputted into species-specific availability bias correction factors using equations from Laake et al. (1997).

Electronic range finder "eRanger"

An electronic range finder "eRanger" is being developed by NEFSC to electronically record the distance between a shipboard observer and a group of animals detected during an abundance survey using high powered 25x150 binoculars ("BigEyes") to search for animals. The major potential advantages of this device are improved accuracy of the distance and inputting this data field directly into a computerized data sheet. An earlier design was tested on a marine mammal abundance cruise in 2012 on board the NOAA Ship *Henry Bigelow* (Figure F1) and it was found a higher resolution inclinometer was needed. At the time it was not possible to find an inexpensive high resolution inclinometer.

During 2015 a higher resolution, inexpensive inclinometer was found and incorporated into a newly designed eRanger. The new design consists of a CH Robotics UM7 Attitude and Heading Reference System (AHRS) (Figure F2) that has an angular resolution of 0.01 degrees in the Roll and Pitch axis. The UM7 AHRS is based on the InvenSense MPU-9250 9-axis motion processing unit (MPU) which incorporates a 3-axis accelerometer, 3-axis gyroscope, and a 3-axis magnetometer into a single micro electro-mechanical (MEM) chip. The UM7 AHRS is connected to the Edison CPU (Figure F3) using a standard UART interface. Currently, the design engineer is developing a circuit board that will provide the electronic interface between the UM7 AHRS and the Edison CPU board, as well as power supply circuitry to power both the UM7 and the Edison. Both the Edison CPU and the UM7 AHRS will be installed in a watertight case, and will be mounted on the BigEyes binoculars. Funding for this project was provided by AMAPPS and NEFSC. AMAPPS funds were used to procure hardware. The engineering effort is being funded through NEFSC.

In this newest design the eRanger operator will be able to control/view output from the eRanger using any device which is capable of connecting to a WIFI hotspot. A Kindle Paperwhite eReader was chosen as the display of choice because of its ability to present sharp clear pictures in any environment, including bright sunlight, although any PC, smart phone, tablet, or eReader could be used as a display. The eRanger has an HTML interface (Figure F4) which allows the operator to enter data, or view the angle/range output of the eRanger. Current plans are to produce one prototype device for testing on one leg of the NEFSC AMAPPS cruise in June or July 2016.

Initial general analyses

Initial analyses were conducted before either of the modeling frameworks was applied. During 2014, these initial analyses were applied mostly to the large whales (fin whales, sei whales (*Balaenoptera borealis*), sperm whales (*Physeter macrocephalus*), humpback whales, North Atlantic right whales (*Eubalaena glacialis*), and minke whales(*B. acutorostrata*)). In 2015, the analyses were expanded to apply to all species detected during all of the shipboard and aerials abundance surveys. These initial analyses included: exploring the statistical relationships between the different environmental variables; exploring the distributions of sightings to define species-specific habitats, if applicable; exploring the detectability of the various species on the different platforms to determine which species could be pooled when estimating the density estimate; exploring the relationship between the density of animals and the environmental variables; exploring the forms of GAM and Bayesian hierarchical models; exploring additional diagnostic tests of the models; and exploring several ways to classify sightings report ambiguously as a fin-sei whale into either a fin or sei whale.

BAYESIAN HIERARCHICAL FRAMEWORK

The Bayesian hierarchical framework used to model and predict the spatial distribution of protected species in the Atlantic Ocean, has been referred to as a "one-stage approach" because both the observation uncertainty and process uncertainty are integrated within one comprehensive modeling framework (Miller *et al.* 2013). The Bayesian approach allows for straightforward probabilistic conclusions to be derived directly from the posterior distributions of the model. In addition, the Bayesian framework allows for prior information to be integrated into future predictions.

During 2015 the focus was on applying the Bayesian hierarchical model to visual data on all large whales species collected in the AMAPPS surveys and using the model output to produce maps of density estimates with appropriate measures of uncertainty. Initial results indicated that median density estimates appeared accurate and comparable to estimates produced from other modeling frameworks, but the uncertainty associated with the estimates was unacceptably high. We worked on several ways to reduce uncertainty as well as considering different approaches for presenting the results in a visual framework. These approaches included redefining the study site for each species to only include areas were each species is likely to occur, looking more closely at possible interactions and reducing the set of explanatory variables to a smaller set of likely predictors. In addition, simulations were used to verify that there are no errors in the code and the model is working appropriately. Unfortunately, there is some evidence that the current framework will result in skewed estimates and hence large uncertainty bounds (Conn et al. 2014, Conn et al. 2015).

Additional work accomplished in 2015 included:

- Implemented fin-sei model that classifies ambiguous sightings of fin and sei whales into one species category or the other and therefore uses the available information more efficiently
- Incorporated Bayesian variable selection (O'Hara and Sillanpää 2009) into the model framework so all covariates could be evaluated simultaneously and model averaged posterior estimates could be produced
- Evaluated approaches to reducing uncertainty by limiting the degree of process variance in the predictions
- Included hazard rate function to give detection function more flexibility
- Created seasonal maps for each species of large whale
- Included estimates of availability bias and uncertainty in model framework

- Derived seasonal abundance estimates for all large whales species from model output
- Summarized habitat relationships for all of the large whales
- Corrected mistakes in input variables and re-ran all models
- Finalized code and methods to streamline process of making spatial predictions from model results.

In the short term, continuing work will focus on 1) soliciting outside reviews of the code and methods to verify that there are no errors in the current model framework and 2) making final decisions on how best to display and communicate the model results for large whales including estimates of model uncertainty.

Longer term goals of projects involving Bayesian analyses include: 1) exploring the best methods to incorporate acoustic data into the modeling framework, 2) exploring the use of nonparametric approaches such as GAMs in the Bayesian framework and 3) implementing state of the art statistical methods for incorporating spatial autocorrelation into the model framework (Shelton et al. 2014). These approaches may help to reduce uncertainty and produce more accurate results.

GENERALIZED ADDITIVE MODELING FRAMEWORK

During 2015, a GAM modeling process was developed following a 4-step process and applied to 16 species (or species groups) data collected during 2010 – 2013, implemented in the R programming language (R Core Team 2014).

For step 1, like species were pooled within platforms (NE aerial, SE aerial, NE ship, and SE ship) to insure sufficient sample sizes and similar detectability characteristics. Appropriate truncation distances and significant covariates (group size, Beaufort sea state, glare severity, observer team) were determined. Then species-specific availability bias correction factors were applied. This resulted in abundance estimates for all grid cells and time frames that had survey effort.

For step 2, the above abundance estimates for surveyed grid cells were modeled using GAMs, where static and dynamic environmental variables were the explanatory variables. Using five diagnostic statistics, and accounting for correlations between the environmental variables, the best fitting model was developed.

For step 3, the above best fitting density-environmental model was used to predict values for all grid cells and time frames of the following variables: density, its coefficient of variation, 95% lower confidence limit, and 95% upper confidence limit.

Finally for step 4, the density estimates within cells of a specified time and area were summed to calculate an average abundance estimate, with its associated coefficient of variation, 95% lower confidence limit, and 95% upper confidence limit. Time periods of interest were the quarterly seasons. Areas of interest included the entire study area and the BOEM leasing and wind planning areas.

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Figure F1. eRanger mounted to BigEyes Binoculars.

Figure F2. UM7 Attitude and Heading Reference System (AHRS)

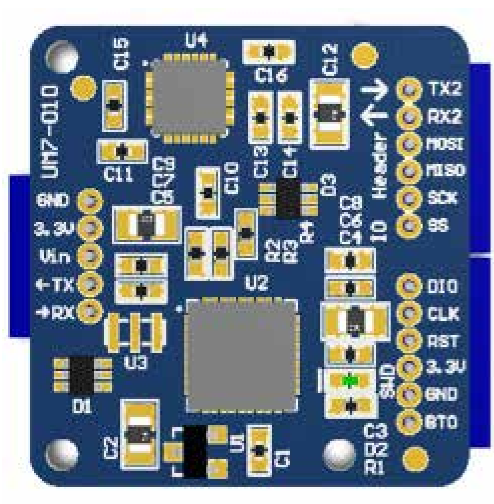


Figure F3. Intel Edison CPU with UART interface.

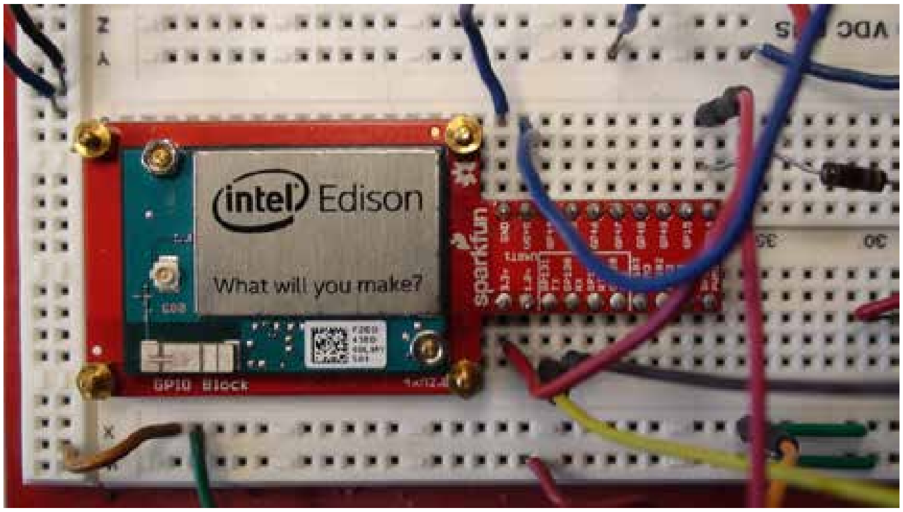
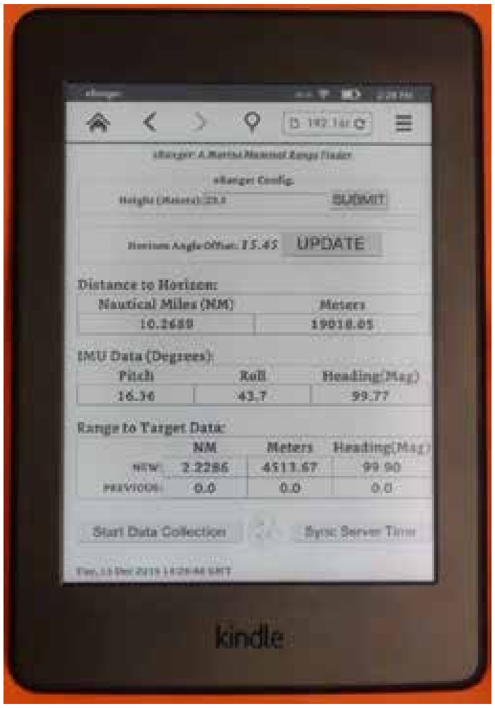


Figure F4. Amazon Kindle Paperwhite eReader.



Appendix G: *Progress on passive acoustic data collection and data analyses: Northeast and Southeast Fisheries Science Centers*

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SUMMARY

The goal of the AMAPPS-related work conducted by the Northeast and Southeast Fisheries Science Center's passive acoustic groups is to collect acoustic data that complement the visual-based analyses of animal occurrence and abundance, particularly for species that are difficult to detect by the visual observers or in times of year and regions where visual surveys are not conducted. Currently, AMAPPS is supporting several projects using bottom-mounted archival recorders, as well as data collection using towed hydrophone arrays during shipboard surveys.

Two new passive acoustic data collection projects using bottom-mounted archival recorders were initiated in 2015; the new east coast Migratory Corridor Project and the Shelf Break Acoustic Ecology project. Both of these projects will expand in 2016 with the deployment of additional recorders. New acoustic data were also collected via towed hydrophone array during the NEFSC 2015 AMAPPS shipboard survey (See Appendices D and E in this document for more information).

In addition to those deployments, there were four primary analysis foci in 2015, involving data collected during previous AMAPPS surveys. These were: (1) estimating the abundance of sperm whales (*Physeter macrocephalus*) using passive acoustics, where the ultimate goal is to integrate these with visual abundance estimates to account for availability bias; (2) quantifying acoustic detection rates for beaked whales and the potential impact of echosounder use on beaked whale detections, with the goals of comparing to visual detection rates and estimating acoustic abundance for this taxon, if possible; (3) documenting the offshore occurrence of baleen whales in the Great South Channel and Georges Bank regions to supplement visual sighting data, and (4) finalizing analyses of geographic variation in the echolocation clicks of Risso's dolphins (*Grampus griseus*).

Additional collaborative projects related to AMAPPS are ongoing with colleagues. This includes the continued contribution of acoustic data to the development of an Atlantic version of the Real-time Odontocete Call Classification Algorithm (ROCCA), where the ultimate goal is to determine which delphinid species may be confidently identified acoustically in the absence of visual species identification. Colleagues at the Scripps Institution of Oceanography are also working on the development of a species-specific classifier using echolocation clicks; the NEFSC and SEFSC are contributing data to those efforts as well. In addition, we continue to work with colleagues on the ongoing development of the Tethys database (http://tethys.sdsu.edu/). Tethys is being developed in collaboration with scientists from the Scripps Institution of Oceanography and the other NOAA Fishery Science Centers, and utilizes standardized formats for archival of metadata associated with acoustic data collection and analyses, including AMAPPS data.

BACKGROUND AND OBJECTIVES

Passive acoustic technologies have become a critical component of marine mammal monitoring, contributing information about the spatial and temporal occurrence, distribution, and acoustic behavior for a variety of species. Some species, such as beaked whales, have low visual detection rates (Barlow *et al.* 2005); while even the more reliably sighted species cannot be detected visually at night or when sighting conditions are poor. Data collected from acoustic studies provide important new insights about species occurrence, including abundance estimation for species that are often poorly detected visually (e.g., Marques *et al.* 2009), presence of species in regions that are difficult to otherwise survey (e.g., Moore *et al.* 2012), and the response of individuals to anthropogenic activities that produce underwater sound (e.g., Castellote *et al.* 2012). Archival recorders, ocean gliders, drifting buoys, and towed hydrophone arrays all offer the opportunity to collect data on cetacean occurrence and distribution that complements traditional visual survey methodologies.

The goals of the passive acoustic groups at the Northeast and Southeast Fisheries Science Centers include improving our understanding of cetacean acoustic ecology, so that we may improve abundance estimation and develop more effective monitoring and management strategies where needed.

The main objectives of incorporating passive acoustic data into the overall AMAPPS project include:

- Improve our understanding of the spatial and temporal distribution and relative abundance of cetaceans along the western North Atlantic using bottom-mounted archival recorders;
- Improve abundance estimates of odontocetes in the western North Atlantic using acoustic data collected from towed hydrophone arrays, particularly for sperm whales, beaked whales, and delphinids;
- Evaluate the efficacy of towed hydrophone array and archival recorder data collection with comparison to traditional visual data collection to determine where data from these different platforms may be integrated.

Both the NEFSC and SEFSC are engaged in a number of passive acoustic monitoring studies that are not supported by AMAPPS. This chapter summarizes activities specifically related to acoustic recorder deployments and passive acoustic data analyses that are part of the AMAPPS project. Additionally, information on towed hydrophone array data collection during AMAPPS shipboard surveys in FY15 is included in other appendices within this report.

I. ARCHIVAL RECORDER DEPLOYMENTS

Two east-coast-wide passive acoustic monitoring projects were initiated in 2015. The first, the Migratory Corridor 2.0 project, included the deployment of 5 lines of MARUs (Marine Autonomous Recording Units, Cornell Univ.) along the western North Atlantic continental shelf (Figure G1). This project builds on an existing analysis of historic data, to describe the current migratory timing and pathway of baleen whales along the eastern seaboard, and to assess changes in movement patterns of animals compared to the past 10 years. The 5 lines of MARUs are distributed between Nantucket, MA and Brunswick, GA. Each line is comprised of 5 – 7 MARUs, programmed to record continuously at a sampling rate of 2 kHz for up to 6 months. At the end of 6 months, they will be recovered and redeployed in the same locations. Deployments of these units took place during October 2015 – January 2016. This project is supported in part by AMAPPS funding.

The second project, Shelf Break Acoustic Ecology, includes the deployment of a series of eight HARPs (high-frequency acoustic recording package, Scripps Institution of Oceanography) along the shelf break, from Georges Bank to the Blake Plateau (Figure G1). Each of these units will record continuously for up to 10 months at a sampling rate of 200 Hz. Three units were deployed during March – June 2015. These will be recovered and redeployed in spring 2016, and five additional units will also be deployed in 2016. This project is funded by BOEM. Initial datasets from both of these projects are anticipated in summer 2016.

II. ACOUSTIC DATA ANALYSES

METHODS

Processing of passive acoustic data took place using a variety of software packages. Automated detection and tracking of sperm whales (*Physeter macrocephalus*) and beaked whales from towed hydrophone array data were conducted using Pamguard (version 1.12.05 Beta, Gillespie et al. 2008), as well as custom-written Matlab scripts. Abundance estimation was conducted using the software package DISTANCE. Bottom-mounted recorder data were reviewed for cetacean acoustic activity using a variety of custom-written software algorithms, including the Low-Frequency Detection Classification System (LFDCS, Baumgartner et al., 2013) for baleen whale vocalizations. Visual and aural reviews of spectrograms and extraction of delphinid whistles were conducted using the software packages Raven (version 1.4, Bioacoustics Research Program 2011) and Xbat (Figueroa and Robbins 2008), executed in Matlab.

RESULTS

Acoustic Abundance Estimates of Sperm Whales: NEFSC & SEFSC

In 2015, SEFSC efforts focused on finalizing sperm whale analyses from the AMAPPS 2013 summer survey. Data were reanalyzed using Pamguard detection and localization algorithms similar to those applied by NEFSC. Approximately 271 sperm whales were detected and localized in two-dimensions acoustically during daytime data collection. NEFSC and SEFSC are currently compiling the results and preparing them for publication.

Acoustic Detections of Beaked Whales (family: Ziphiidae): NEFSC & SEFSC

Three main analyses were conducted in 2015 regarding acoustic detection rates of beaked whales via towed hydrophone array: i) distribution of detections on shipboard surveys, ii) assessing the effect of echosounder use on beaked whale visual and acoustic detections, iii) preliminary analyses of 3-D localization of beaked whales using acoustic data.

i) In 2015, two shipboard survey datasets were analyzed: the NEFSC 2015 AMAPPS survey (HB15-03), and the SEFSC 2013 AMAPPS survey (GG13-03). The two legs of the HB15-03 survey were geared primarily towards baleen whales and turtles, respectively (see Appendices D and E in this report); therefore towed array data collection was limited. However, despite limited effort, there were 34 definite beaked whale acoustic detections in 41 hrs of data (Tables G1 – G2, Figure G2). In 2013, the NEFSC and SEFSC undertook wide-scale cetacean abundance surveys; with the analysis of the SEFSC 2013 survey data, acoustic detection rates have now been quantified for the entire AMAPPS 2013 cetacean abundance survey. In the GG13-03 survey, over 400 hrs of data were analyzed, resulting in only 7 definitive beaked whale detections (Tables G1 – G2, Figure G3).

ii) During the NEFSC AMAPPS 2011 and 2013 shipboard cetacean abundance surveys (HB11-03 and HB13-03), the NEFSC conducted an experiment to test whether the use of shipboard echosounders affected detection rates of beaked whales. Shipboard echosounders were alternated between active and passive modes every other day. Analyses of these data are now completed. Visual sightings of beaked whales were included from both surveys, while acoustic detections were only used from the 2013 survey (due to complications with the hydrophone array in 2011). A total of 256 groups were sighted across both surveys, and at least 116 beaked whales were detected acoustically during the 2013 survey (Figure G4). A regression analysis using Generalized Linear Models (GLMs) was conducted; the results suggest that while sea state has the most impact on visual sightings of beaked whales, echosounder use had a significant negative impact on acoustic detection rates. A manuscript is currently being prepared with these data.

iii) The NEFSC AMAPPS 2013 survey data were also used for a pilot project to test whether using towed array data beaked whales could be localized in 3-D which would allow extracting information on dive depths during an acoustic encounter. Sixty-seven acoustic events with high-quality two-dimensional locations were chosen for further analysis, of which depth information could be calculated for 41 of these events. Depths for Cuvier's beaked whales averaged 1107 m, and depths for Gervais' beaked whales averaged 808 m (Figure G5). A manuscript is currently being prepared with these data, and the project will be expanded in 2016 to include collaborators with additional datasets.

Baleen Whale Occurrence in the Northeast Offshore Region

Ten archival, bottom-mounted Marine Acoustic Recording Units (MARUs, Cornell University) were deployed along the shelf break from the northern region of Georges Bank to Hudson Canyon on the NEFSC April 2014 AMAPPS shipboard survey. The units were programmed to record continuously, at a sampling rate of 2 kHz. Nine units were successfully recovered in September 2014; of these, eight recorded for the entire deployment period, while one unit failed several weeks after the initial deployment. In addition, one Autonomous Multichannel Acoustic Recorder (AMAR, Jasco Applied Science) was deployed off Georges Bank and recorded data from July 2014 – May 2015. This unit was programmed to record on a duty cycle, sampling both at 250 kHz and 16 kHz. Acoustic data from both of these projects have been extracted and are currently being analyzed. While neither of these projects was funded by AMAPPS, the deployments and/or recoveries of these units were coordinated with AMAPPS shipboard surveys.

Geographic Comparison of Risso's Dolphin Echolocation Click Features

Passive acoustic monitoring for density and abundance estimation using towed arrays is particularly successful for acoustically-active deep-diving species with a known visual detection bias (e.g. low *g(0)*) and call types that are identified to species. Additionally, spatio-temporal trends in odontocete occurrence can be extracted from fixed acoustic recorders, if call types are distinctive and recognizable to species. Existing methods may be applicable to blackfish, including Risso's dolphins, if echolocation clicks can be properly classified.

A large-scale comparison of the spectral features of Risso's dolphin echolocation clicks was conducted at the SEFSC as part of a collaborative effort with researchers at the NEFSC, SEFSC, Pacific Islands Fisheries Science Center, Scripps Institution of Oceanography (SIO), Duke University Marine Laboratory, and others. The goals of this project were to: 1) determine if Risso's dolphins around the globe exhibit similar spectral banding patterns to those found off southern California which allow them to be acoustically classified, and 2) determine if there are geographically-driven differences among the acoustic frequencies of spectral bands which may indicate population structure. A draft manuscript on these results was prepared in 2015.

Ongoing Collaboration to Develop Species-Specific Acoustic Classifiers for Odontocetes

ROCCA: An algorithm for classifying delphinid whistles to species called the Real-time Odontocete Call Classification Algorithm (ROCCA) has been developed by Dr. Julie Oswald (Biowaves). In 2012, both NEFSC and SEFSC contributed data for the development of an Atlantic species-specific version of ROCCA. The first Atlantic version of ROCCA was completed and implemented into the software platform Pamguard in 2013. This version includes automated whistle classifiers for five species (*Globicephala sp., T. truncatus, D. delphis, S. frontalis, S. coeruleolaba*). Biowaves is currently expanding and refining the classifier based on testing results; the NEFSC continues to provide data for ongoing classifier development.

SIO: SEFSC has provided SIO researchers with visually-verified single-species recordings of delphinids from 2011 and 2013 towed array surveys. SEFSC is currently analyzing these data using Pamguard to calculate bearings to clicks and extract bearing tracks from individual delphinids and delphinid groups. This will be used to 1) ensure automatically detected clicks represent true clicks and not random noise, 2) localize groups to ensure visual and acoustics are a true match, i.e. acoustics are not from an unseen group, 3) account for individual variation when developing automated click classifiers, and 4) eventually can get incorporated into target motion analyses for density estimation.

DISPOSITION OF DATA

Acoustic data are stored on-site at the Northeast Fisheries Science Center and the Southeast Fisheries Science Center.

ACKNOWLEDGEMENTS

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Table G1. Towed hydrophone array data that were analyzed in FY15 for the presence of beaked whales.

Survey	Number of days surveyed acoustically	Hours of data collected	Hours that could not be analyzed
HB15-03	7	41.52	3.24
GG13-03*	27	411.43	6.08

*10 days were excluded from analysis due to overlapping coverage

Table G2. **Acoustic detections of beaked whales and number of individuals localized (in parentheses) in analyses of NEFSC 2015 (HB15-03) and SEFSC 2013 (GG13-03) AMAPPS shipboard survey data. Positive, probable and possible indicate the degree of certainty that a given acoustic event is correctly classified as a beaked whale.**

Survey	Species	Positive	Probable	Possible
HB15-03	Cuvier's	27 (24)	1 (1)	8 (1)
	Gervais	6 (5)	1 (1)	6 (0)
	Sowerby's	1 (0)	3 (0)	1 (0)
	TOTAL	**34 (29)**	**5 (2)**	**15 (1)**
GG13-03	Cuvier's	5 (1)	8 (1)	2 (0)
	Gervais	0 (0)	0 (0)	0 (0)
	Sowerby's	0 (0)	0 (0)	0 (0)
	Blainville's	2 (1)	0 (0)	0 (0)
	TOTAL	**7 (3)**	**8 (1)**	**2 (0)**

Figure G1. Map showing new acoustic recorder deployments that are part of the Migratory Corridor 2.0 (yellow pentagons) and the Shelf Break Acoustic Ecology (triangles) projects. MARUs were deployed during October 2015 – January 2016; three HARPs were deployed in 2015; the others will be deployed in 2016. The positions shown on this map are approximate locations.

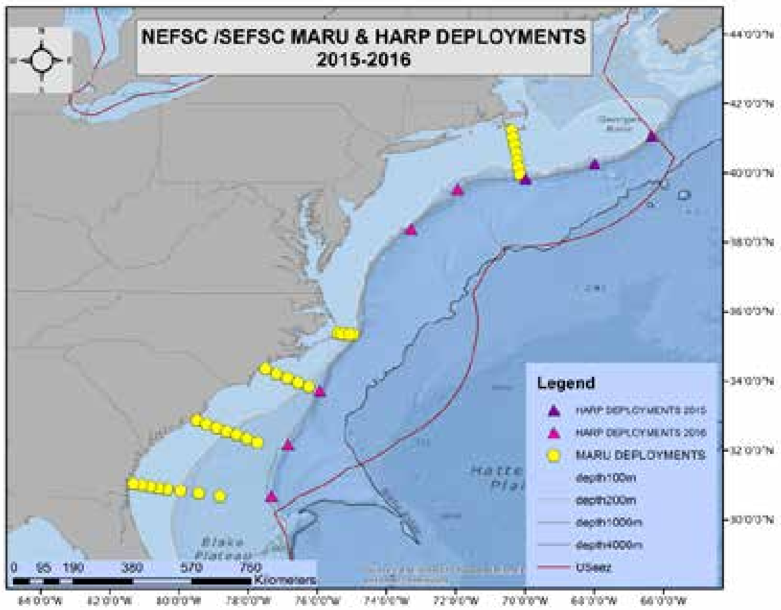


Figure G2. Map showing tracklines during which the towed hydrophone array was deployed on both legs of the AMAPPS 2015 shipboard survey (HB15-03). See Appendix D for more information about those surveys and data collection. Dots indicate acoustic detections of beaked whale species. The shipboard EK60 echosounders were operated in passive mode during all hours in which the hydrophone array was deployed.

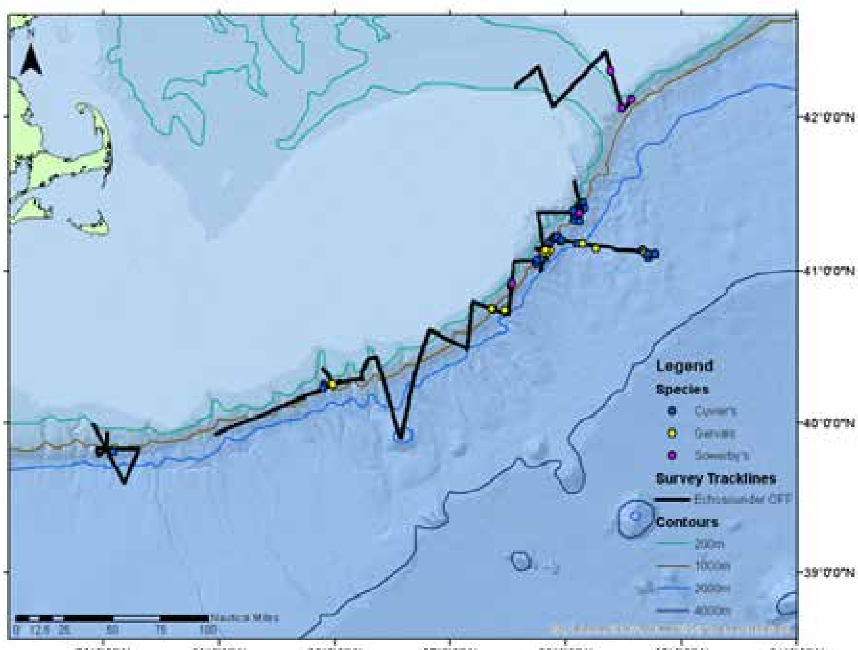


Figure G3. Map showing tracklines during which the towed hydrophone array was deployed during the SEFSC 2013 AMAPPS shipboard survey (GG13-03). See the AMAPPS FY13 annual report for more information about data collection on that survey. Dots indicate acoustic detections of beaked whale species. The shipboard EK60 echosounders were operated in active mode during this survey.

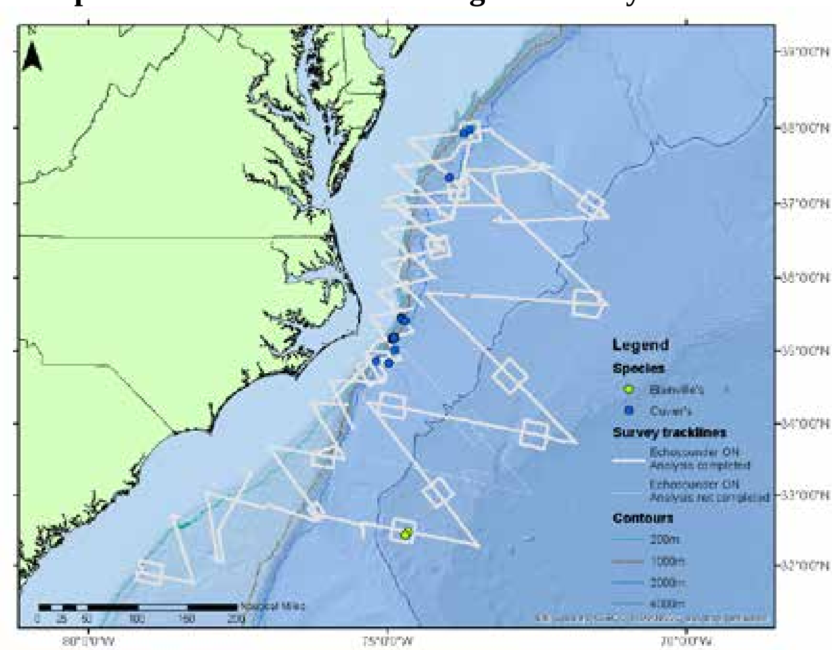


Figure G4. Map showing tracklines during which the towed hydrophone array was deployed during the NEFSC 2013 AMAPPS shipboard survey (HB13-03). Shipboard EK60 echosounders were alternated between active and passive mode during this survey. See the AMAPPS FY13 annual report for more information about data collection on that survey. Dots indicate acoustic detections of beaked whale species.

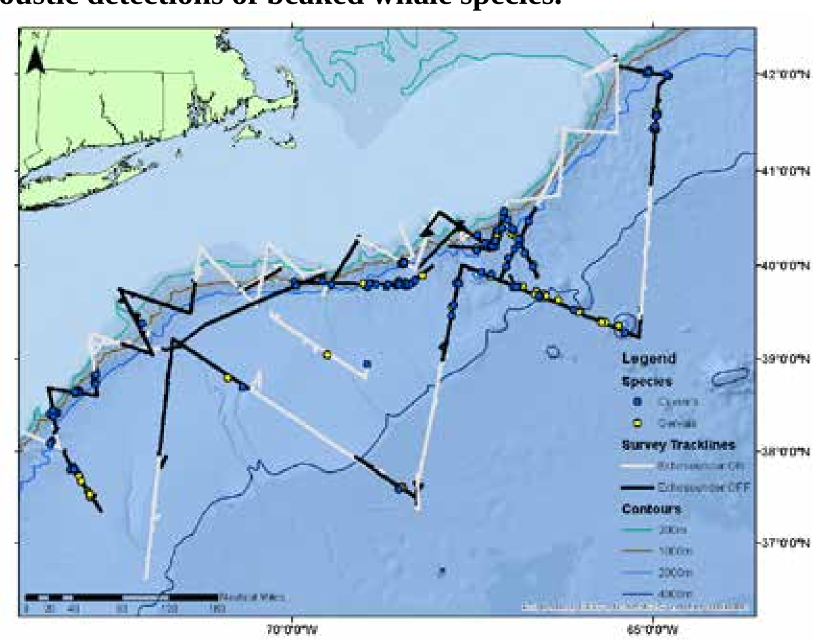
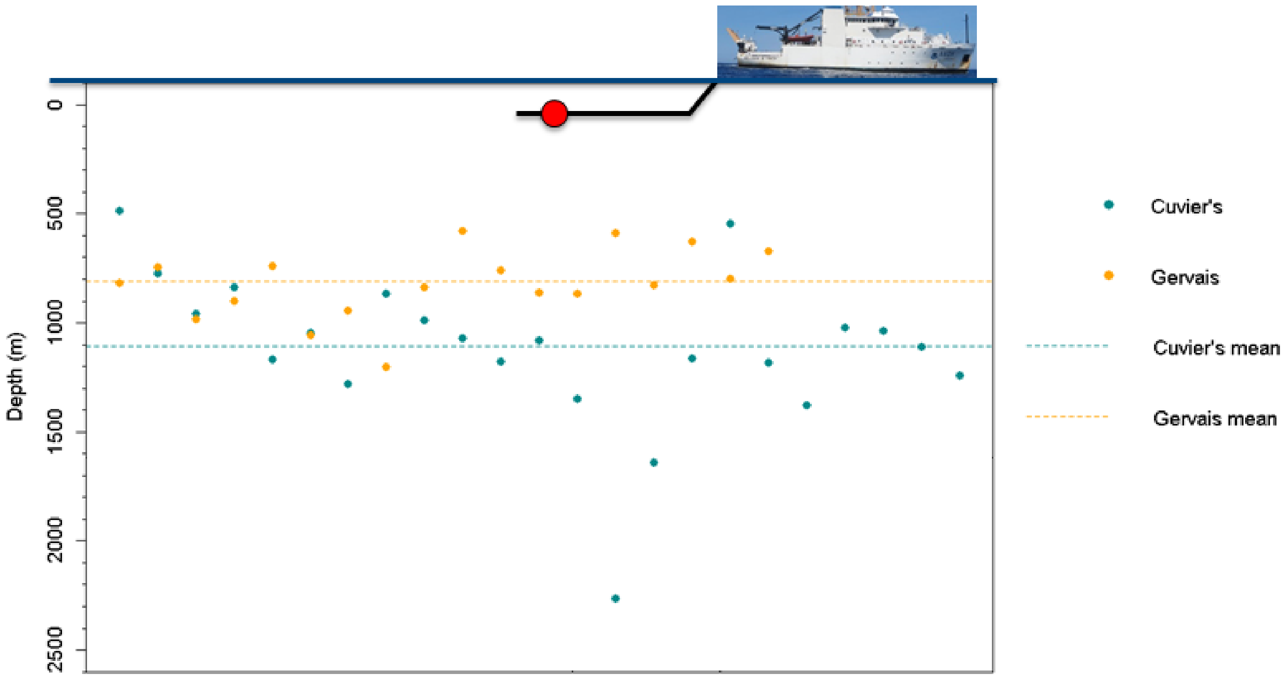


Figure G5. Dive depths of Cuvier's (n=23 animals) and Gervais' (n=18 animals) calculated using the towed hydrophone array data collected during the NEFSC 2013 AMAPPS shipboard survey (HB15-03).



Appendix H: *Progress on analyses of oceanographic, acoustic, and plankton data: Northeast Fisheries Science Center*

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SUMMARY

To gain a better understanding of the underlying processes that may drive the distribution and abundance of predators, such as marine mammals, sea turtles, and sea birds, the relationships between hydrographic characteristics of the water column and distributions of lower trophic level organisms, such as fish and plankton, are being compared to the distribution patterns of the above protected species predators. Data were collected during shipboard surveys conducted during the 2009, 2011, 2013, 2014 and 2015 AMAPPS Northeast Fisheries Science Center's surveys. Throughout the years, physical water characteristics and distribution and densities of various fish and planktonic trophic levels were documented using the following: Seabird 19+ and 911 conductivity-temperature-depth (CTD); Video Plankton Recorder (VPR); 61cm bongo net; 1-m^2 Multiple Opening/Closing Net Environmental Sensing System (MOCNESS); 6 ft and 10 ft Issac Kidd Midwater Trawls (IKMT); midwater trawls; paired go-pro video cameras; Didson high definition imaging sonar; and multifrequency Simrad EK60 echosounders. This appendix focuses on the hydrographic and lower trophic data collected on the two legs of the 2015 NOAA ship *Henry B. Bigelow* summer survey. The first leg circumscribed Georges Bank, and the second leg searched for turtles in waters on the southern edge of Georges Bank to Canadian waters (See Appendices D and E for more details). In addition, this appendix provides an update on the progress made to analyze previously collected data: post-processing the physical oceanographic data, enumerating the biological samples, and comparing the distributions of cetaceans and zooplankton relative to the distribution of potential prey detected by the EK60.

BACKGROUND AND OBJECTIVES

One of the objectives of the AMAPPS initiative is to develop spatially explicit density maps of cetaceans, sea turtles, and sea birds that incorporate environmental habitat characteristics. To describe the environmental habitat characteristics of the marine mammals, sea turtles, and sea birds detected on the shipboard surveys, environmental sampling procedures were designed to determine distributions of lower trophic levels and physical oceanography. Hydrographic, active acoustic and plankton data were collected during the 2009, 2011, 2013, 2014, and 2015 AMAPPS Northeast Fisheries Science Center (NEFSC) surveys which were used to map the lower trophic levels and oceanographic conditions of the study area.

METHODS

During 2015, physical water characteristics and distribution and densities of various fish and planktonic trophic levels were documented using: Seabird 19+ and 911 CTD, Video Plankton Recorder (VPR), 61cm bongo net, a midwater trawl, paired go-pro cameras, a Didson (dual frequency identification sonar) high definition imaging sonar, and multifrequency Simrad EK60 echosounders. The daytime sampling schedule was set by the visual observation teams. Bongo and hydrographic samples were collected along the visual-observation transect line three times daily and a hydrographic cast was made at the start and end of each day's line to provide sound speed data for the active and passive acoustic sampling.

In 2015 nighttime sampling varied between the two cruise legs. On the first leg, midwater trawls were deployed on biologically interesting features that were observed in the multi-frequency active acoustic data during the day or in areas of marine mammal concentrations. Sites were selected based on communication with the day watch and small-scale transects were conducted to confirm the presence of acoustic features before trawl hauls were conducted. On the second leg sampling emphasis was placed on gelatinous zooplankton found in areas where sea turtles were captured. Since gelatinous zooplankton is damaged by nets and thus not sampled quantitatively, three imaging systems were deployed in addition to the bongo nets. Oceanographic transects were conducted across interesting features caused by two warm core rings in the sampling area.

IMAGING SYSTEMS

VPR tows used a Seascan V-fin mounted, internally recording, black and white VPR. The VPR was also equipped with a Seabird Fastcat CTD, a Wetlabs fluorometer / turbidity sensor and a Benthos altimeter. The VPR sampled at 16 frames per second with each frame representing a known volume of water. A second SEACAT 19+ CTD profiler was mounted above the V-fin to provide real time data on gear depth and oceanographic conditions. Tows were conducted at 3 – 4 kts speed through the water to minimize image frame overlap. VPR tows were conducted in two formats: in a tow-yo fashion, oscillating between the surface and a predetermined depth, and in a stepped double oblique tow to match the Go-Pro and Didson deployments.

Upon retrieval, the compressed data from the VPR were downloaded to specialized image processing computers. Data were decompressed, oceanographic data files were created, and in focus regions of interest (ROIs) were extracted from each image frame using Autodeck programming from Seascan. Interpolated profiles of temperature, salinity, density, raw chlorophyll and raw turbidity values were created for each tow-yo type haul using MATLAB. Hauls from 2015 have only temperature, salinity, and density profiles. Each haul's ROI set was processed to remove images taken during deployment and retrieval. ROI sets were further processed to remove duplicate images caused by frame overlap of multiple grabs of larger taxa. ROIs were then identified to general taxonomic grouping using a modified version of Visual Plankton developed by Cabell Davis of the Woods Hole Oceanographic Institution.

Larger gelatinous plankton were targeted using a dual visual sampling platform (Figure H1). The first system was a Sound Metrics Didson 300 imaging sonar mounted in a steel cage. The Didson was set to sample a small area, with a focus of 1.04 m. The second system was a video net. It consisted of two Go-Pros facing each other separated by 148.2 cm and boomed out 70 cm. With the cameras set to 1080 wide and the refraction of the water, this allowed the overlapping video coverage of the two cameras to record one square meter when dropped vertically though the water column. A Star-Oddi DST–CTD was also attached to the platform to record water quality. A mechanical flow meter was mounted on a rod perpendicular to the Go-Pro booms to measure the water current during cast stops. Both the Didson 300 and the Go-Pro video system sampled the same area. During the cast the platform was lowered to 100 m then brought to the surface pausing for 2 min at 7 depths (100, 75, 50, 40, 30, 20, and 10 m).

BONGO DATA

Plankton and hydrographic sampling was conducted by making double oblique tows using the 61cm bongo net and a Seabird 19+ CTD. The tows were made to approximately 5 m above the bottom, or to a maximum depth of 200 m. All plankton tows were conducted at a ship speed of 1.5 – 2.0 kts to create a wire angle of 45°. The bongo was deployed approximately three times a day: once before the day's surveying started (about 0500 – 0530), at lunch time (about 1200 when the ship stopped surveying), and again after surveying was completed for the day (approximately 1800, depending on weather and timing of the sunset). Bongos were also deployed at night or on demand during the day to fill special sample requests.

OCEANOGRAPHIC SAMPLING

In addition to the Seabird 19+ deployed with the plankton nets and imaging systems a Seabird 911 CTD with a 12 Niskin bottle rosette was deployed opportunistically to generate oceanographic transects across canyons, across the shelf slope area and across oceanographic features like the Gulf Steam or warm core rings. The Seabird 911 was deployed in a vertical fashion to within 10 m of the bottom while the ship was holding stationary.

MIDWATER TRAWL

A modified Marinovich midwater trawl (i.e., “shallow water midwater trawl”) was used as the primary trawl to sample pelagic fish and macrozooplankton. The shallow water midwater trawl was deployed with 1.8 m superkrub doors, 100 lb tom weights, 30 fathom bridles, and was fished at about 3 kts. The mouth opening when “fishing” was approximately 6 x 8 m (horizontal x vertical). The codend liner was ¼ in. knotless nylon. A polytron midwater rope trawl was brought as a backup, but was not deployed. The midwater trawl was monitored during deployment by a Simrad FS70 trawl sonar mounted on the head rope, and by two Vemco temperature-depth recorders with one mounted on the head rope and one on the foot rope. The FS70 provided real-time data, which were recorded to a file and archived at the NEFSC. The Vemco recorders were initialized immediately prior to each deployment and the data were downloaded to a PC after each deployment.

Midwater trawls were deployed to sample acoustic backscatter observed in the multifrequency acoustic data and decisions on where and when to sample were made on an *ad hoc* basis depending on the observed backscattering patterns. Tow depths and durations were not standardized, i.e., depth and duration were set for each trawl and were not consistent among trawls hauls.

SIMRAD EK60

Acoustic backscatter data were collected using multifrequency (NOAA ship *Henry Bigelow*: 18, 38, 70, 120, and 200 kHz. Active acoustic data (when the EK60 transmits a sound pulse (i.e., “ping”) and listens for echoes) were collected continuously during nighttime. In addition, active acoustic data were generally collected during daytime, but the EK60 was set to passive mode towards the end of leg 1. During periods where active data were not collected, the EK60 was set to passive mode (when the EK60 only listens and there is no transmit pulse). The purpose for collecting data in passive mode was to evaluate whether the EK60 affected marine mammal behavior. The EK60s were set to transmit at 1 ping per second, which allowed the EK60s to ping as fast as they could, given the sample range of 3000 m and signal processing time. In general the EK60s transmitted once every 5 – 6 sec when off the continental shelf. In active mode, each frequency transmitted a 1-ms CW pulse.

The EK60s were calibrated for the bottom trawl survey that had ended prior to the beginning of the 2015 marine mammal survey using the standard target method at the Newport Naval Anchorage. A 38.1-mm tungsten carbide with 6% cobalt binder sphere was suspended at about 20 m range from the transducers and was used to calibrate all frequencies. A wireless calibration system, consisting of three remotely controlled downriggers, and automated software were used to initially position the target under the split-beam transducers and the software automatically moved the sphere throughout the acoustic beams. The data were collected and then the Simrad Lobe program was used during data playback for each EK60 individually.

RESULTS

The processing status of data collected since 2009 is presented in Table H1.

VPR DATA

The 2015 oceanographic data from the VPR mounted environmental sensors (Figure H1) have been plotted to characterize the sea turtle sampling areas as collected during leg 2 (Figure H2). The water column showed a steady thermocline between 20 and 80 m. Sea surface temperatures (SST) were around 15°C warmer than historical SST derived from satellite data. Salinity profiles had little variation from the surface to 100 m depth and salinity values were over 36 psu, while normal salinities in the area are usually below 33 psu (Figure H2). This indicates that most of the sampling area was inside a water mass with strong Gulf Stream influences. Satellite AVHRR composite imagery from the sampling area (Figure H3) confirmed this by showing two large warm core rings along the Georges Bank shelf-slope front.

Towed type sampling, such as VPR hauls, around the sampling area was difficult to conduct on a regular schedule due to the amount of fixed gear and numerous fishing vessels in the area so only four VPR hauls were completed.

Seacat 19+ CTD data from the first upcast of each haul hav been processed and posted to the oceanography branch website (http://www.nefsc.noaa.gov/epd/ocean/MainPage/).

Previous VPR plankton ROIs (extracted images) have been used to create several classification databases for various camera settings. Each taxonomic level, grouped by the lowest taxonomic grouping possible, have 300 images. Image sets were combined into larger groupings to create a a generic plankton classifier for each camera setting to run on the ROIs from each individual VPR haul.

The generic classifier originally used to process the 2015 ROIs had seven categories:

- *Gelatinous* – salps, ctenophores, hydromedusae, dolids, Scaphozoa
- *Marine snow*
- *Crustacea* – Euphasiids (krill), Hyperidea, Gammaridea, shrimp
- *Copepoda* – copepods, Brachyura zoea, Ostrocoda
- *Phytoplankton*
- *Line like* – Larvacean, Chaetognatha (arrow worm), Polychaeta, rod type phytoplankton
- *Other* – larval fish, veligers, unknowns, pteropoda….

Post identification MATLAB routines to create plots and databases were run to describe a lower trophic level, thus furthering the AMAPPS goals. Spreadsheets were created that include oceanographic data, numeric plankton densities and plankton size data. Data can be interpolated in both time and/or depth bins allowing for a wide variety of visualizations. Data are available upon request.

VPR hauls from 2015 were conducted in a double oblique pattern with a steplike upcast (Figure H2) to match the tow profile of the Didson/Go-Pro hauls. Due to the early summer sampling time frame VPR hauls had very low concentrations of plankton and even lower densities of the targeted gelatinous zooplankton. In all hauls densities of gelatinous zooplankton were too low for any quantitative analysis. In response to a special request, gelatinous zooplankton images were hand identified to the lowest taxonomic level possible. These data will be compared to data from the Lugols solution preserved plankton nets, and the images from the Didson, and Go-Pros.

During 2015, the VPR data from 2013 were hand corrected to create more detailed taxonomic zooplankton distributions and to provide a ground truth data set to quantify automated identification accuracy. To create more specific size and body type categories for comparison with the EK60 ROI categories several VPR categories were split into lower taxonomic levels: *Crustacea* was split into *Amphipoda* and *shrimplike, Pteropoda* and *Ichthyoplankton* were pulled from *Unknown, Gelatinous* was split into small single organisms (individual salps, hydromedusa, ctenophores) and large colonial organisms (salp chains, siphonophores), and *Chaetognatha* were pulled from *Linelike.*

All categories have been binned to match the EK60 processed data. Formulas are being developed to compute the time delay between each EK60 data bin and VPR data bin because the VPR samples water slightly behind the ship, while the EK60 samples water directly below the ship. This will allow the direct comparison of plankton densities and the 200 kHz and 120 kHz scattering signals from the active acoustics. Using the newly created categories for backscattering strength, calibrations will begin to determine if the acoustic signal is affected by the type of plankton present and the size limitations of each frequency. Categories will be compared in various combinations to determine the best fit with the EK60 backscatter and to help refine the 200 kHz and 120 kHz acoustic ROI categories.

At sea observations from the 2011 – 2015 cruises have suggested that small, insubstantial plankton like marine snow, phytoplankton, and hydromedusa are imaged by the VPR but are not ensonified by the 200 kHz frequency. It is possible high densities of these small plankton may be detected by the EK60. Turbidity and plankton data from several hauls in 2013 and 2014 with very high marine snow or phytoplankton densities will be used to test the effect of high densities of microplankton, not detected individually by the 200 kHz frequency, on the backscattering signal strength.

In 2013 eight of the hand corrected hauls were conducted on Nantucket Shoals. These hauls revealed strongly variable species aggregations across the length of the shoals and encompassed an area with numerous larval fish, a gastropoda spawning event, and *Gammarus annulatus* swarming. The hauls will be used to document environmental variability on Nantucket Shoals and to study plankton patchiness in spawning and swarming events.

VPR data from 2013 are also being used to quantify the error of the automated image ID program. Data from each haul were processed in three different ways: computer processed, computer processed with a confusion matrix correction, and computer processed then hand corrected. The hauls are being compared to generate a percent error value and to analyze the value of time consuming hand corrections for different type sampling objectives.

DIDSON/ GO-PRO DATA

Analysis of the imaging systems data is still ongoing. There were few large organisms present in the water column, thus it is hard to assess the effectiveness of the Didson acoustic imaging. The Go-Pro system was able to capture images of some small organisms, but image blurring makes identification difficult.

NET PLANKTON DATA

During 2015 bongo samples were collected from 22 casts at 20 sites (Figure H4). The 2015 bongo samples were shipped to the Polish Sorting Center for processing. The zooplankton from the 6BZ nets were split to subsamples of 500 – 1000 individuals and identified to the lowest possible taxonomic and life stage level possible and enumerated. All ichthyoplankton from the 6BI nets were identified to the lowest taxonomic level possible, enumerated, and the standard lengths of a subset measured. Completed data from 2007 – 2014 have been loaded into the NMFS oracle plankton database. Eight samples from HB1503 6BZ net were preserved in acid Lugols solution to better preserve the gelatinous zooplankton. These eight samples were sent to Michael Ford at the NMFS Silver Springs office for identification.

Identification of the ichthyoplankton from the 2011 and 2013 cruises included larval bluefin tuna, *Thynnus thynnus* (Figure H5). The known spawning area for northwestern Atlantic (west of 45° W) population of Atlantic bluefin tuna is April – May in the Gulf of Mexico. Transport times derived from drifter tracks and the length derived age of the larvae suggest these larvae were not transported by the Gulf Stream from the Gulf of Mexico spawning area. The presence of this species in the off-shelf plankton samples may represent a new slope sea spawning area (Richardson et al. 2016). Further offshore sampling is planned to confirm and delineate the new spawning area.

The MOCNESS, 6 ft IKMT and 10 ft IKMT samples from 2013 and 2014 have been processed. All ichthyoplankton was removed, identified to the lowest taxonomic level possible, enumerated, and preserved in ethanol for additional study. Each net sample was split to subsamples of 500 – 1000 individuals and identified to the lowest possible taxonomic and life stage level possible and enumerated. Data have been loaded into the NMFS Oracle plankton database. The stratified zooplankton data will be used in conjunction with the bongo, midwater trawl, and the IKMT data to aid in the ground truthing of the EK60 sorting categories, which are as follows: fish-like, euphausiid-like/ micronekton, copepod-like/zooplankton, and other.

MIDWATER TRAWL

Twenty-one midwater trawl deployments were conducted in June 2015 (Table H2 and Figure H6). Trawl catches were sorted to species, each species weighed *en masse*, and up to 150 individuals were randomly (or all if less than 150 individuals) selected for fork length measurements. Species composition reflected the area where the tows occurred. In the Georges Bank area (tows 2 – 15), tows consisted of krill (*Meganyctiphanes norvegica* and likely other species), shrimp (*Pandalus* sp.), jellyfish (primarily salps), and fish species such as Atlantic herring (*Clupea harengus*), butterfish (*Peprilus triacanthus*), silver hake (*Merluccius bilinearis*), and Acadian redfish (*Sebastes fasciatus*). The tows at the shelf break and deeper (tows 17 – 24) were dominated by mesopelagic species such as myctophid species, snipe eels (*Nemichthys* *scolopaceus*), dragonfish (*Gonostomatidae* sp.), hatchetfish (*Sternoptychidae* sp.), as well as invertebrate squid and octopus species.

SIMRAD EK60

Multifrequency echosounder data were collected continuously in either active or passive mode during leg 1 of HB201503 (Figures H7 – H8). Data during 11 – 15 and 18 – 19 Jun 2015 were collected to 500 m and data collected during other times collected to 2500 m. The depth of 500 m was selected for data collected on the continental shelf and Georges Bank, and 2500 m was selected for data collected at the shelf break and in deeper water. All data on the shelf and on Georges Bank were collected in active mode. Data collected at the shelf break and in deeper water were collected in either active or passive mode. EK60 data were stored on a portable hard drive, archived at the NEFSC, and sent to NOAA's National Center for Environmental Information (aka National Geophysical Data Center in Boulder, CO) for permanent archive.

All EK60 data were post-processed during the survey. Post-processing of active acoustic data involves removing the echo from the seabed and any electronic, acoustic, or bubble noise.

Multifrequency S_v echograms highlight a variety of acoustic backscattering patterns that are indicative of the spatial and temporal distributions of multiple trophic levels, and some of the patterns are unique to specific species, times, and locations (Figures H9 – H11). Figure H9 highlights a biophysical interaction with small gas-bearing organisms entrained in an internal wave near the sea surface (upper right relative frequency response suggests small gas-bearing organisms such as siphonophores), as well as “speckles” of individual gas-bearing fish just beneath the internal wave (upper left relative frequency response suggests gas-filled swim bladder-bearing fish), a layer of small gas-bearing organism in the mid water column (lower left panel), and fish without a gas-filled swim bladder such as butterfish (*Peprilus triacanthus*) and/or Atlantic mackerel (*Scomber scombrus*) near the bottom (lower right relative frequency response suggests fish without any gas-filled swim bladder). A spawning aggregation of Atlantic herring (*Clupea harengus*) on Georges Bank was observed acoustically (Figure H10) and from trawl catches. Atlantic herring are not thought to spawn during spring in the Gulf of Maine (or spring spawning is inconsequential to the population) so this provides direct evidence of at least some spawning on Georges Bank in the spring/early summer. Mesopelagic fish dominate acoustic backscatter at/near the shelf break (Figure H11), where certain species (primarily myctophid species) migrate from 400 – 600 m depths to near the surface at night (relative frequency responses suggest small organisms and fish with gas-bearing swim bladders) and other species stay at depth.

RELATING PREY TO MARINE MAMMAL DISTRIBUTION

Work has begun to relate marine mammal presence to prey density in the shelf-slope frontal region. Through the use of multifrequency echosounder data (EK60) we aim to explain some degree of the patchiness seen in marine mammal distribution. These echosounding data will be complemented by data collected at point locations or over short distances such as CTDs, XBTs, VPR, and net tows.

We have begun processing the EK60 data to classify organism types following the methods outlined in Trenkel and Berger (2013) who classified organisms into four major scattering groups using distinctive acoustic frequency responses from each group. These groups included swim bladder fish, small gas bearing organisms such as larval fish or phytoplankton, fluid-like zooplankton such as copepods and euphausids, and larger fish without a swim bladder, such as mackerel. Additional sub-classification may be possible if organisms are distinct within these broader groups. Classification to species cannot often be resolved with only echosounder data, although species ID can be confirmed using biological sampling conducted concurrently as was done with the midwater trawls and VPR. Illustrations of similar classification can be seen in Figures H9 – H11.

Once the echosounder data are processed to organism type, track lines will be processed to identify schools of prey and quantify prey density, biomass, and prey depth at varying spatial scales. These data will then be examined in conjunction with marine mammal sightings (and absences) and passive acoustic detections to develop multi-species or multi-guild habitat models for the shelf break region along the track line. These models will be based primarily on measures of prey in the water column in an attempt to discern ecological niches. They would complement current abundance models and in the future could provide a prey component that could be incorporated as an additional parameter into current abundance model techniques.

ACKNOWLEDGEMENTS

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Trenkel, VM, Berger L. 2013. A fisheries acoustic multi-frequency indicator to inform on large scale spatial patterns of aquatic pelagic ecosystems. Ecological Indicators 30:72-79.

Table H1. Processing status of oceanographic and plankton samples. Complete = data are available, identified = sample is processed but data have not yet been posted to a database, shipped = sample is in Poland being identified, in progress = samples are being processed.

Cruise		**HB0903**	**HB1103**	**HB1303**	**GU1402**	**HB1403**	**HB1503**
CTD	# Sta	65	104	242	202	15	53
	Status	complete	complete	complete	complete	complete	complete
Bongo Z	# Sta	25	85	83	125	11	26
	Status	complete	complete	complete	complete	complete	shipped 11/2015
Bongo I	# Sta	24	84	81	125	11	26
	Status	complete	complete	complete	complete	complete	shipped 11/2015
VPR TowYo	# Sta	25	46	16	8	0	4
	Status	complete	complete	complete	complete	NA	complete
VPR Fixed	# Sta	0	35	14	0	0	0
	Status	NA	complete	complete	NA	NA	NA
MOC 1m I	# Sta	0	0	8	1	0	0
	Status	NA	NA	75 nets complete	7 nets complete	NA	NA
MOC 1m Z	# Sta	0	0	8	1	0	0
	Status	NA	NA	75 nets complete	7 nets complete	NA	NA
MOC/VPR	# Sta	0	0	8	none	0	0
	Status	NA	NA	complete	NA	NA	NA
IKMT 6'	# Sta	0	0	10	1	0	0
	Status	NA	NA	complete	complete	NA	NA
IKMT 10'	# Sta	0	0	0	0	1	0
	Status	NA	NA	NA	NA	complete	NA
Midwater	# Sta	0	0	0	0	3	21
	Status	NA	NA	NA	NA	complete	complete
Didson	#Sta	0	0	0	0	0	8
	Staus	NA	NA	NA	NA	NA	processing
Go-Pro	#Sta	0	0	0	0	0	16
	Staus	NA	NA	NA	NA	NA	processing

Table H2. Midwater trawl dates, times in GMT, and positions for HB201503. Time and position are the start of the trawl deployment which was defined as when the trawl doors entered the water.

Station	Date and Time (GMT)	Latitude	Longitude
2	12/06/2015-02:38:50	41 17.290 N	69 07.447 W
3	12/06/2015-05:47:45	41 20.287 N	69 01.197 W
4	13/06/2015-01:16:22	41 56.679 N	68 03.200 W
5	13/06/2015-03:10:36	41 56.266 N	67 50.363 W
6	13/06/2015-05:53:25	41 57.227 N	67 59.656 W
7	14/06/2015-00:01:14	42 13.003 N	67 24.239 W
8	14/06/2015-02:15:00	42 09.77 N	67 26.13 W
9	14/06/2015-04:36:30	42 04.323 N	67 27.113 W
10	14/06/2015-06:51:28	42 09.159 N	67 23.941 W
12	15/06/2015-01:20:51	42 14.472 N	66 24.226 W
14	15/06/2015-03:59:23	42 16.908 N	66 24.188 W
15	15/06/2015-06:07:49	42 10.346 N	66 25.160 W
16	15/06/2015-07:53:04	42 12.355 N	66 25.349 W
17	16/06/2015-01:45:42	42 12.185 N	65 13.296 W
18	16/06/2015-06:40:53	42 02.653 N	65 42.900 W
19	17/06/2015-00:06:15	41 08.742 N	66 12.497 W
20	17/06/2015-03:49:24	41 09.265 N	66 13.133 W
21	17/06/2015-05:37:50	41 07.755 N	66 13.568 W
22	18/06/2015-01:18:52	40 16.986 N	67 19.371 W
23	18/06/2015-04:17:58	40 24.730 N	67 16.722 W
24	18/06/2015-06:41:11	40 23.277 N	67 14.922 W

Figure H1. Go-Pro and Didson cage (left) and VPR (right)

Figure H2. VPR haul profile showing salinity (psu), temperature (°C) and the step type deployment.

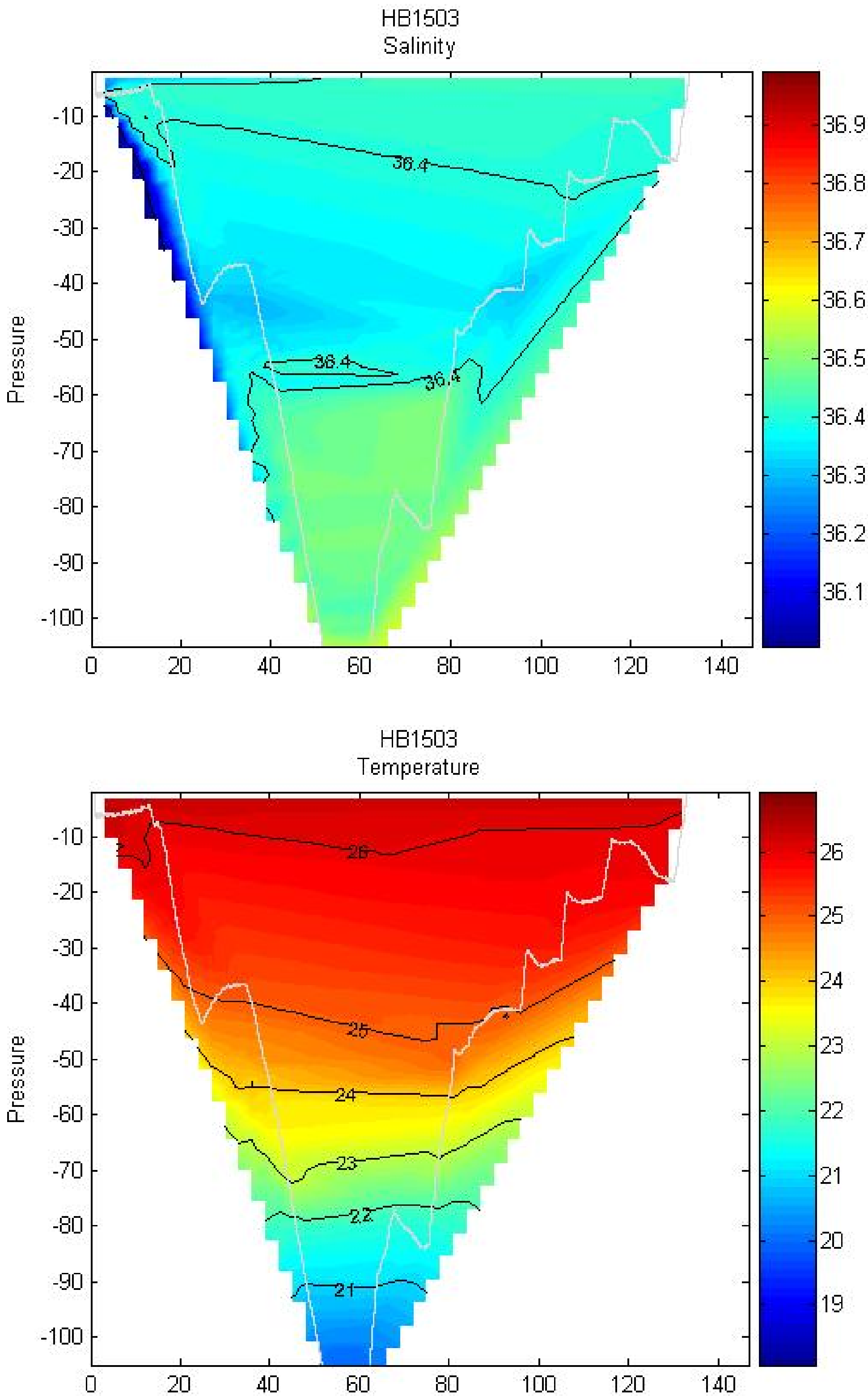


Figure H3. AVHRR satelite sea surface temperature image on 15 June 2015 of the study area showing the location of the two warm core rings.

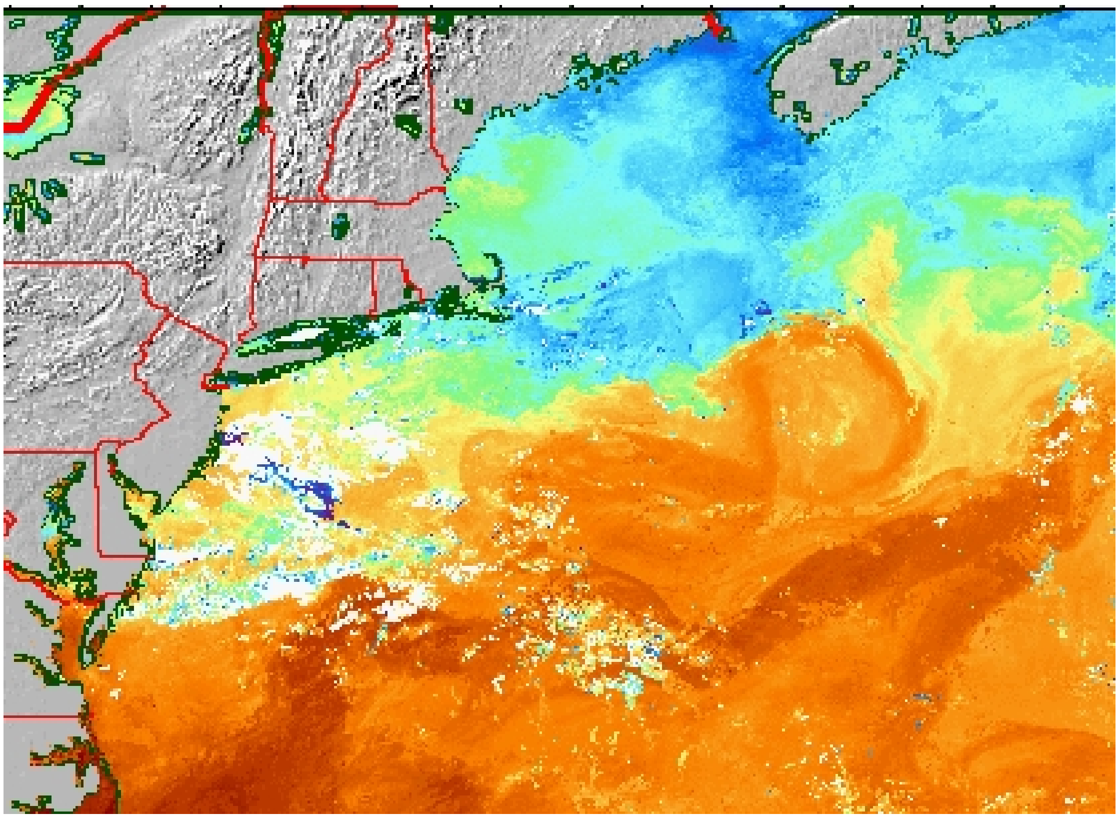
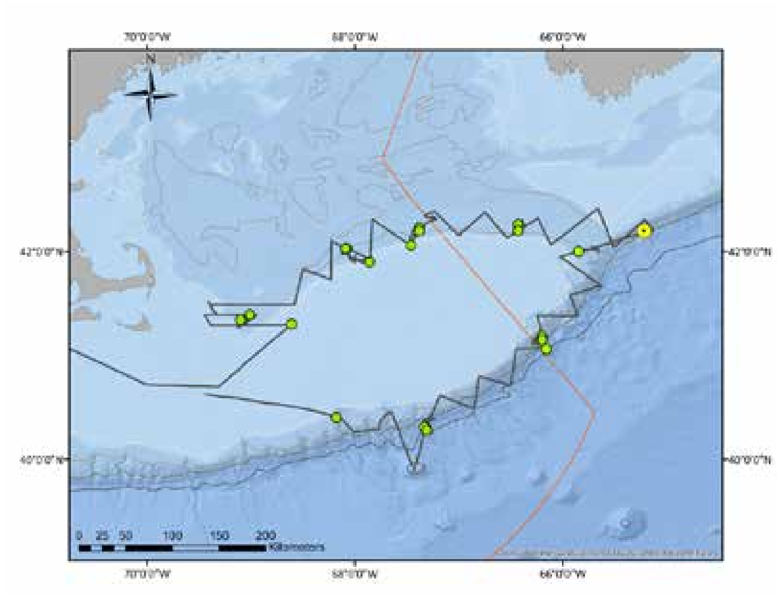


Figure H4. Locations of the deployment of CTD and bongo (green dots), SBE 9/11+ (yellow dot) and VPR (yellow triangles) during HB15-03 Leg 1 (A) and Leg 2 (B).

A.



B.

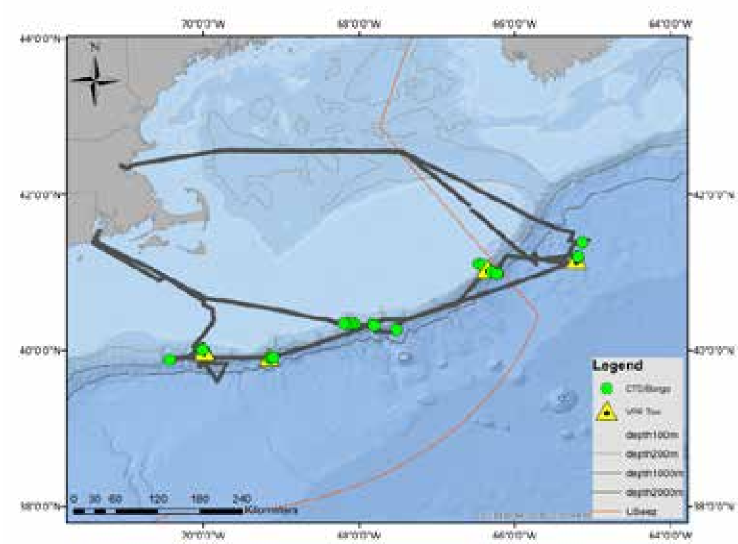


Figure H5. Locations of larval bluefin tuna (*Thynnus thynnus*) from HB1103 and HB1303. The black line is the shelf break and the dotted line is the average Gulf Stream edge position.

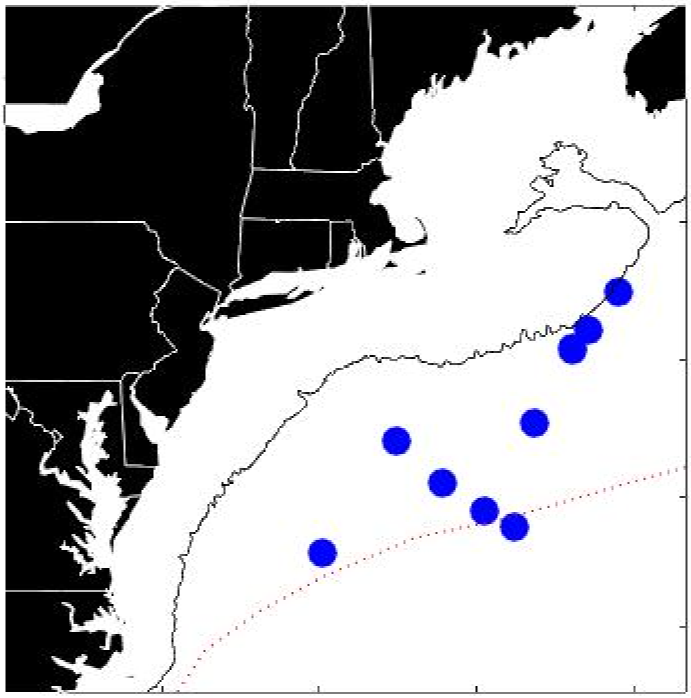


Figure H6. Midwater trawl locations (diamond symbols) and station number.

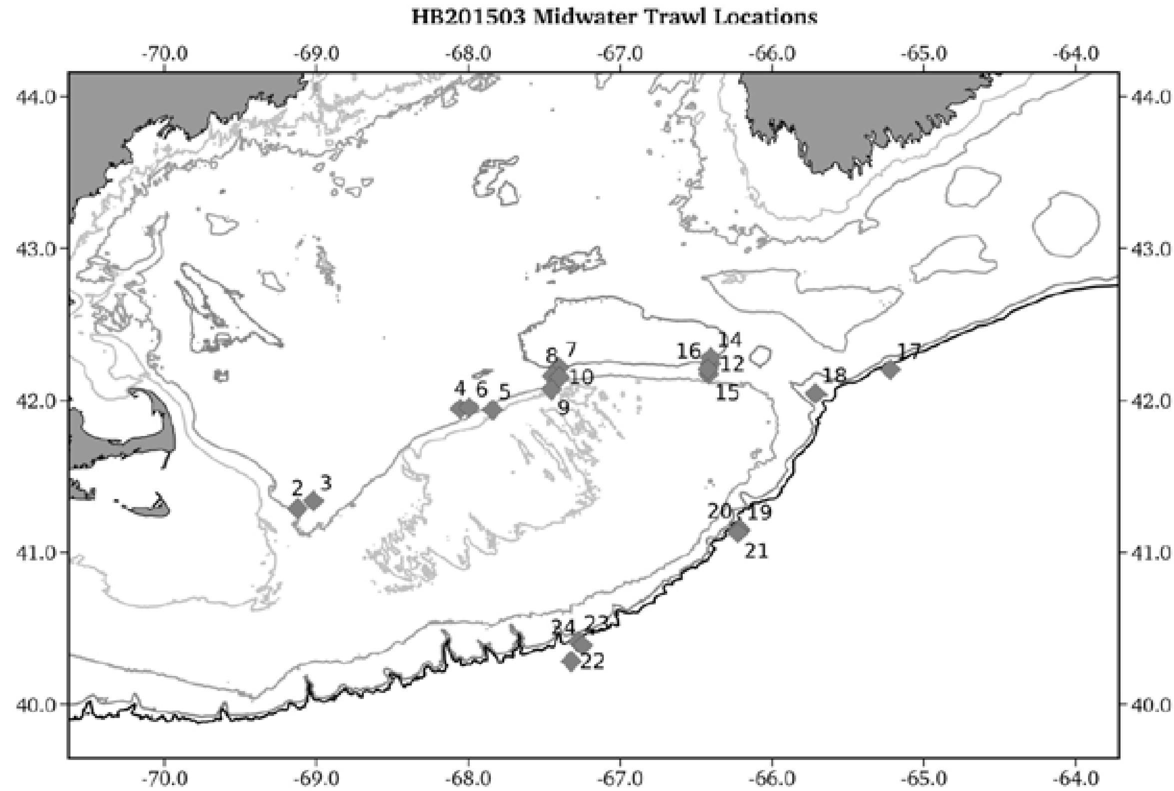


Figure H7. Multifrequency Simrad EK60 data acquisition periods (gray shaded periods on the left side of each day) and postprocessed periods (hatched periods on the right side of each day) for HB1503. All EK60 data were "active" except for the times noted in the gray shaded when all frequencies were recorded in passive mode. Data during 11 – 15 and 18 – 19 Jun 2015 were collected to 500 m and those during 16 – 18 Jun were collected to 2500 m.

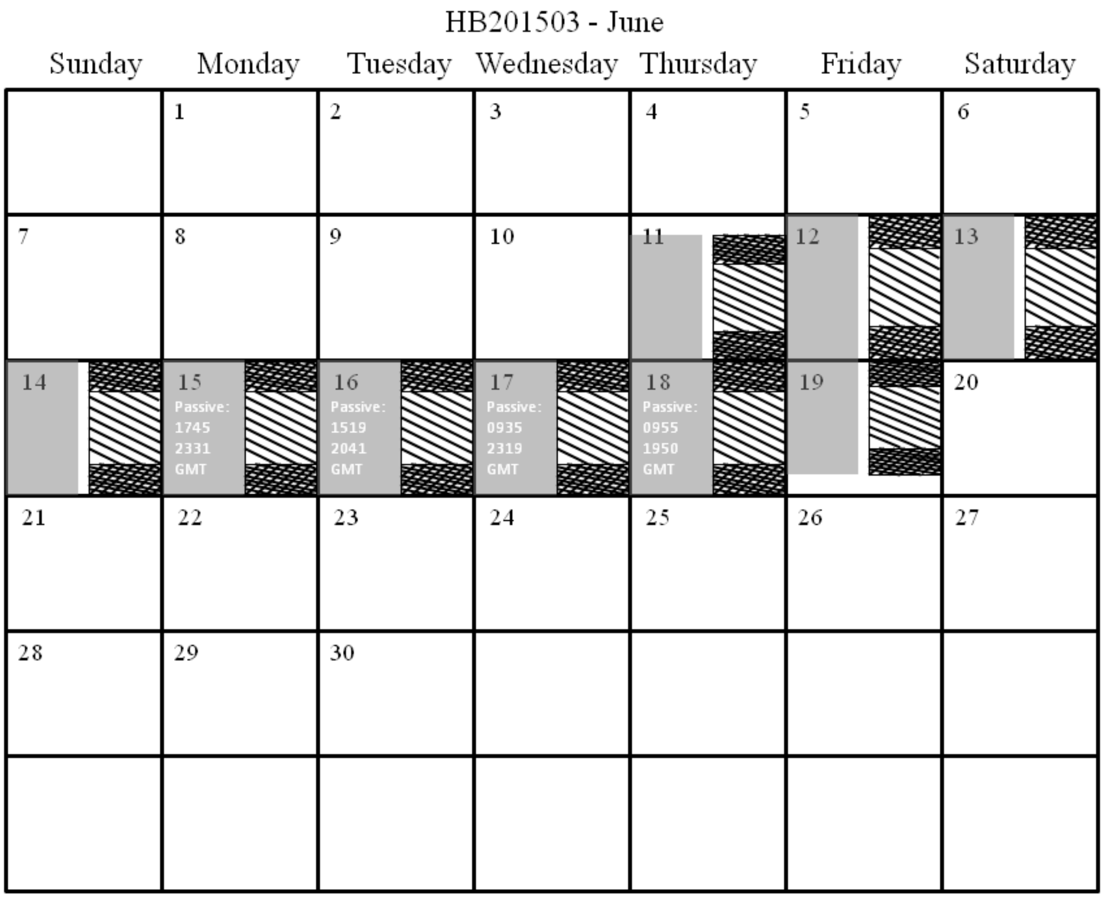


Figure H8. Multifrequency Simrad EK60 data acquisition tracks (black line) for HB201503.

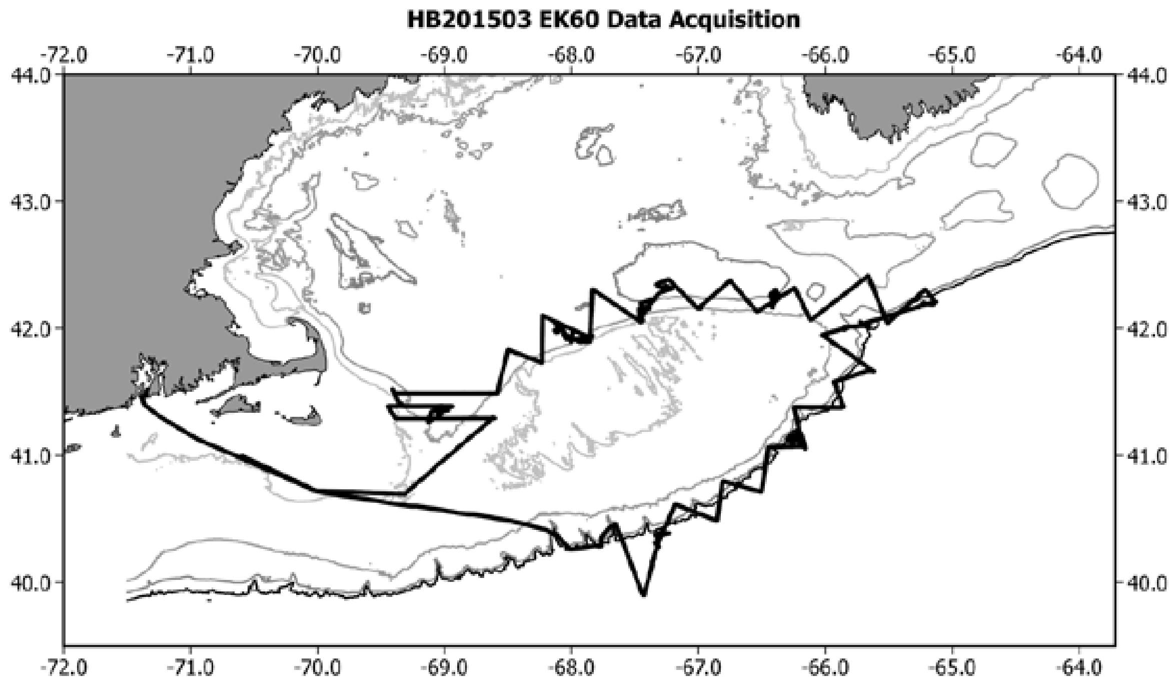


Figure H9. 18, 38, 70, 120, and 200 kHz Sv echograms and relative frequency response graphs for selected regions in the echograms (polygons). Data were collected on 12 Jun 2015 in the Great South Channel area. The depth of the echograms is 175 m and horizontal lines are at 50 m intervals.

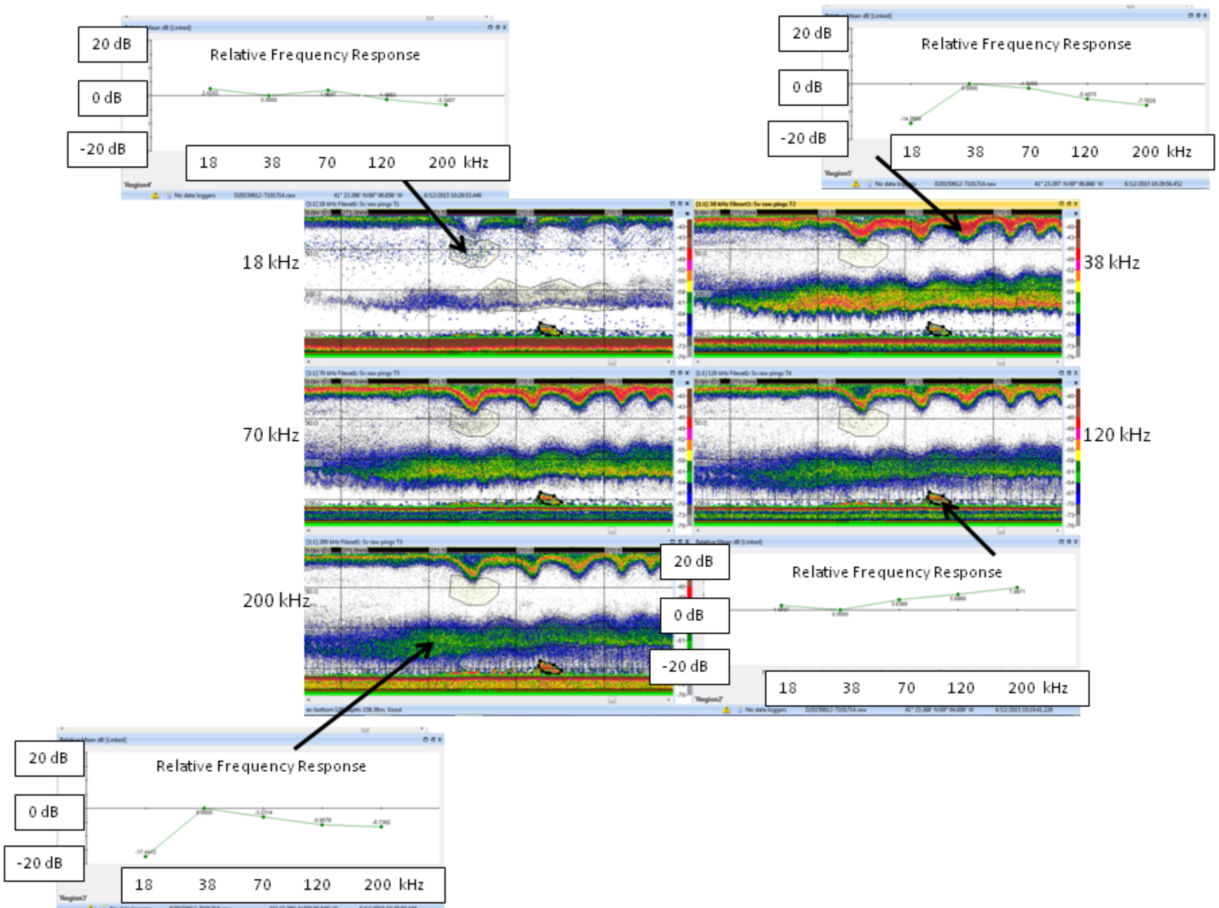


Figure H10. 18, 38, 70, 120, and 200 kHz Sv echograms and relative frequency response graphs for selected regions in the echograms. Data were collected on 13 Jun 2015 in the Georges Bank area. The depth of the echograms is 175 m and the horizontal lines are at 50 m intervals.

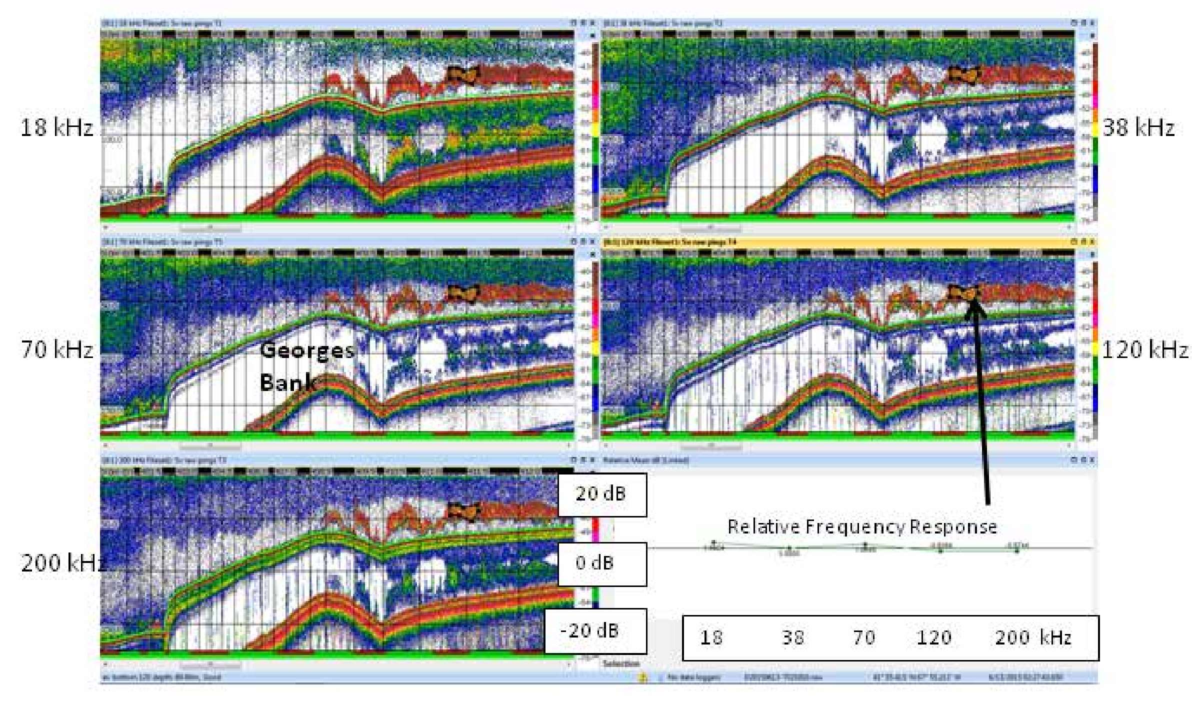
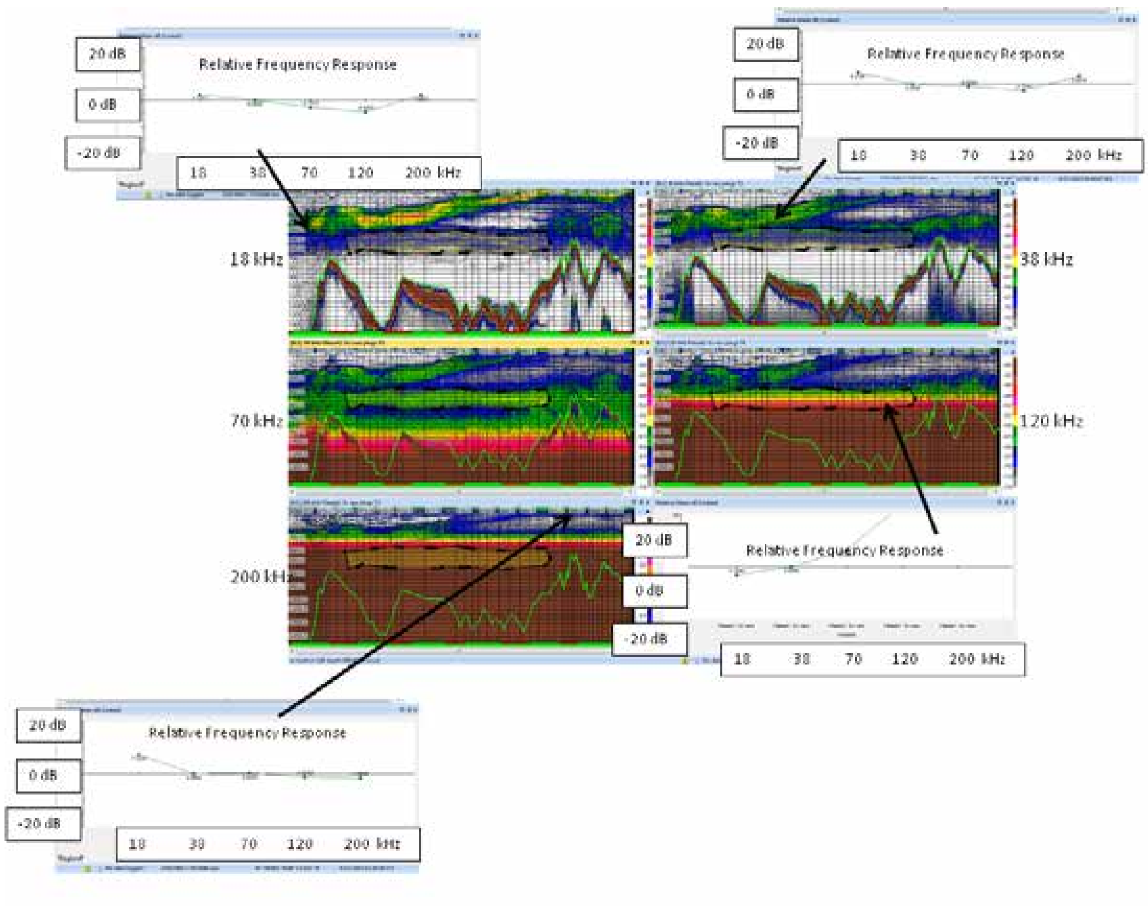


Figure H11. 18, 38, 70, 120, and 200 kHz Sv echograms and relative frequency response graphs for selected regions in the echograms. Data were collected on 16 – 17 Jun 2015 in the shelf break area. Depth of the echograms is 1500 m and the horizontal lines are at 50 m intervals.



Appendix I: *Progress on the development of the Oracle database and of a web-based interactive map to display the modeled density results: Northeast and Southeast Fisheries Science Centers*

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SUMMARY

During 2015, NEFSC expanded its Oracle database to include the 2014 and 2015 AMAPPS related field data. Queries and procedures were further developed to output survey data from the Oracle database in formats appropriate for Distance analysis as well as for other modeling objectives and to streamline the mapping of the seasonal spatially-explicit density distributions. In addition, a web-based interactive interface is being developed that will display the seasonal species density distribution maps and summarize density and abundance estimates for user-specified regions.

OBJECTIVES

One of the objectives of the AMAPPS initiative is to quantify abundance and spatial distribution and to produce spatially-explicit density distribution maps that incorporate habitat characteristics.

To do this a database has been developed to store and optimize retrieval of the data collected during the surveys, as well as the satellite and model-derived environmental data.

In addition, to allow easy access for managers and the public to the spatially-explicit density distribution maps, a web-based interactive interface is being developed.

2015 ACTIVITIES

ORACLE DATABASE

During 2015, the NEFSC continued to expand its Oracle database. In 2015 the major activities included:

1. Adding the visual sightings and turtle tag data from the 2014 and 2015 field activities.

2. Developing queries for combining and outputting survey and environmental data in formats for direct consumption by the Distance sampling program, as well as for other modeling efforts.

3. Developing the maps of the seasonally spatially explicit density distributions which resulted from the modeling work described in Appendix F.

3. Working toward standardization of data collection methods and data structures across AMAPPS NEFSC and SEFSC partners.

WEB SITE

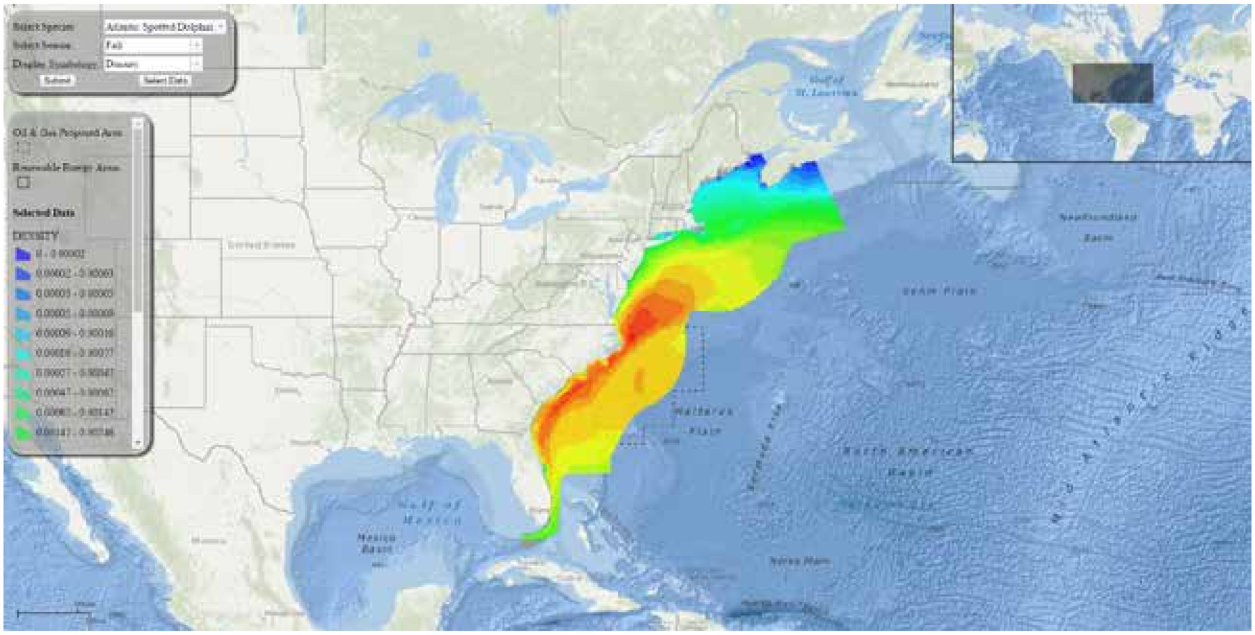
During 2015 we started developing a web-based interactive interface to display the seasonal spatially-explicit density distribution maps and summarize density/abundance estimates. To facilitate ease for a user to query a map to obtain detailed information on specific areas of interest, the web page will have the capability for a user to draw a box around an area of interest. Then for that area, the density and abundance estimates will be summarized, and all of the information for each grid cell within the area will be displayed and will be able to be downloaded (Figure I1).

ACKNOWLEDGEMENTS

The Oracle databases were originally developed and funded by the NEFSC. Since 2010 the updates of the database to incorporate the AMAPPS data were funded by the Bureau of Ocean Energy Management (BOEM) and the US Navy through two Interagency Agreements for the AMAPPS project. The website is being developed and funded by the NEFSC.

Figure I1. A) An overview of the beta-website that displays the seasonal spatially-explicit density maps for cetacean species and B) a summary of a user-specified region marked in the red box.

A.



B.